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MAMMALS
OF
MARYLAND

NORTH AMERICAN FAUNA

NUMBER 66

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE

NORTH AMERICAN FAUNA

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MAMMALS
OF
MARYLAND

By
John L. Paradiso

NORTH AMERICAN
FAUNA

NUMBER 66

UNITED STATES
DEPARTMENT OF THE INTERIOR
Walter J. Hickel, *Secretary*

BUREAU OF SPORT FISHERIES AND WILDLIFE
John S. Gottschalk, *Director*

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INTRODUCTION

In 1950, Marshall C. Gardner (1950a, 1950b) began the first comprehensive listing of Maryland mammals, but he completed only the sections dealing with marsupials, insectivores, and bats. This has been the only statewide study of Maryland mammals ever undertaken, although a number of sectional accounts have appeared, including those by Goldman and Jackson (1939), Bures (1948), Hampe (1939), and Bailey (1923). In addition, Mansueti (1950) treated in detail the extinct and vanishing species of the State.

The present survey originated in the mid-1950's, but intensive work on it was not begun until 1962. During the course of the study, field work was conducted in all parts of the State except the Allegheny Mountain section. Specimens collected during this field work, and the large series of Maryland mammal specimens available in the national collections, form the basis for the present survey. In the "specimens examined" sections of the following accounts, the specimens are in the collections housed in the U.S. National Museum unless otherwise noted. Abbreviations used in the text for other institutions from which material has been examined are K.U. for Museum of Natural History, University of Kansas, U. Mich. for Museum of Zoology, University of Michigan, and U. Md. for University of Maryland. All measurements given in the accounts are in millimeters.

Several species are included in the body of the text for which there are as yet no valid records for the State. These have been indicated by placing the common names in parentheses. They are included because of the virtual certainty that they are a part of Maryland's mammal fauna. Of one of these species, a specimen was taken in West Virginia only a few feet from the Maryland state line; as for the others, Maryland contains abundant suitable habitat and they are known to occur both north and south of the State.

Distribution maps have been prepared for all land species except introduced forms and certain ones that have been restocked or are so widespread in distribution that they have been recorded from every county in the State. On the maps, crosshatched areas represent probable distribution, shaded symbols indicate specimens examined, unshaded symbols indicate published records or other reports that appear to be valid, and an unshaded symbol with a dot in the center indicates a type

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locality. When more than one species or subspecies is represented on a single map, circles and triangles are used to distinguish them, and the crosshatchings representing their probable distributions run in different directions.

I want to express my thanks to Theodore A. Bookhout and Vagn Flyger of the University of Maryland's Natural Resources Institute for contributing a number of Maryland mammal records. I also want to acknowledge my gratitude to the late Romeo Mansueti of the Chesapeake Biological Laboratory, Solomons, Md., for his encouragement and advice on a number of distributional problems.

LOCATION AND AREA OF MARYLAND

Maryland lies between the parallels of 35° 53′ and 39° 44′ north latitude and the meridians 75° 4′ and 79° 29′ west longitude. It is bounded on the north by the State of Pennsylvania and on the east by the State of Delaware and the Atlantic Ocean. The southern boundary of the State is the Potomac River which separates it from Virginia and West Virginia. West Virginia also borders Maryland on the west. The District of Columbia is a political entity on the Potomac, between Prince Georges and Montgomery counties, Maryland. It is not physiographically distinct from Maryland in any way, and herein is regarded as a part of Maryland.

The Maryland Geological Survey lists the total area of the State as 12,300.21 square miles, of which 2,437 square miles are water. Thus the total land area of Maryland is 9,863.21 square miles, making the State the eighth smallest in the Union. The area of the District of Columbia is some 70 square miles, of which 8 are water.

Maryland extends in a general ESE–WNW direction for about 320 miles; the greatest north-south distance is approximately 150 miles. The State is actually a narrow cross section of the Coastal Plain, the Piedmont Plateau, and the Appalachian ridges. Elevations pass gradually from sea level to 3,342 feet on Backbone Mountain in Garrett County.

Geologically, Maryland varies greatly. Formations range from the most ancient granite and gneiss, through rocks of every age and great mineralogical diversity down to the coastal deposits of Recent times. Overlying these rock formations are a great diversity of soils. In contrast to its more northern neighbors, Maryland has never been glaciated.

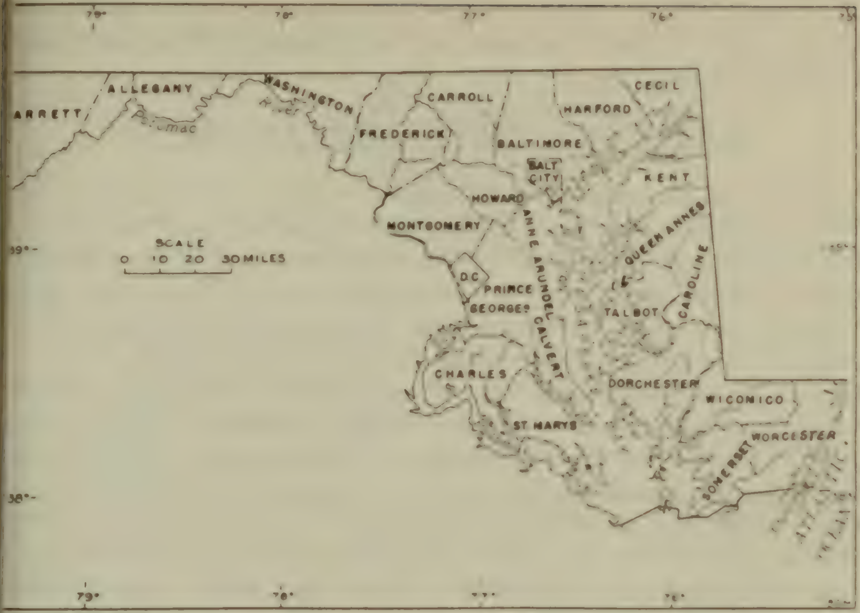

FIGURE 1.—Map of Maryland showing the 23 counties, Baltimore City, and the District of Columbia.

TEMPERATURE

The mean annual temperature for Maryland is 53 to 54 degrees. It varies from area to area, the greatest difference being between Worcester County on the Eastern Shore and Garrett County in the Allegheny Mountains: according to Shreve et al. (1910), the average annual temperature at Sunnyside in Garrett County is 47.1 degrees, whereas at Pocomoke City in Worcester County it is 58, a difference of 11 degrees. At intermediate points the average annual temperatures are also intermediate; the differences that exist are due to such factors as elevation and proximity to the ocean and Chesapeake Bay. The average date for the last killing frost in spring in western Maryland is the first week in May; farther east it is the last 10 days of April. In western Maryland the average time for the first killing frost in autumn is late September; in the eastern part of the State it is early November.

AVERAGE ANNUAL PRECIPITATION

Precipitation is distributed throughout the year, but with a somewhat greater amount in the warmer months than in the cold season. The heaviest rainfall, from 38 to 46 inches, occurs in western Maryland.

The Coastal Plain receives between 40 and 44 inches each year. Calvert County is one of the driest areas of the State and receives only about 36 inches yearly.

EFFECTS OF CIVILIZATION

Maryland, like most other eastern States, has no truly virgin areas. Even in the remotest regions of the western part of the State, logging has been conducted, and fields and pastures range well up onto the sides of the mountains. Some of the wildest parts of the State, until quite recently, were the marshes that lined both the eastern and the western sides of Chesapeake Bay and those along the Atlantic Ocean. With the expanding populations of both Washington and Baltimore seeking areas for summer recreation, many of these marshes are being drained and "improved" for human habitation. In addition, easy access is now available to the outer barrier beach on Assateague Island. The suburban communities of all the larger cities of the State are spreading farther and farther into the countryside and have eliminated some fine woods, swamps, and meadows. This is particularly true of Baltimore and Washington, the suburbs of which now extend 25 miles or more into the surrounding country. As a result, the site where the only specimen of the rare pigmy shrew, *Microsorex hoyi winnemana*, has ever been taken in Maryland is now part of a housing project, and the southeasternmost Coastal Plain locality for the southern bog lemming, *Synaptomys cooperi*, has met the same fate. Nevertheless, a number of areas remain in Maryland which are relatively isolated and which support a varied and abundant mammal fauna. Some species, such as the white-tailed deer and the cottontail rabbit, have actually profited by the changes man has brought to the State.

PRINCIPAL BIOTIC OR NATURAL AREAS IN MARYLAND

Maryland lies in 5 major physiographic provinces (Fenneman, 1938): Coastal Plain, Piedmont, Blue Ridge, Ridge and Valley, and Appalachian Plateaus.

There are three major forest regions (as described by Braun, 1950) in Maryland which correspond roughly to these physiographic provinces. They are the Oak-Pine Forest, the Oak-Chestnut Forest, and the Mixed Mesophytic Forest. Stewart and Robbins (1958) divide these major forest regions of Maryland into biotic or natural sections that represent areas showing floral or faunal differences of a secondary nature. They divide the Oak-Pine Forest region into an Eastern Shore section, an Upper Chesapeake Bay section, and a Western Shore sec-

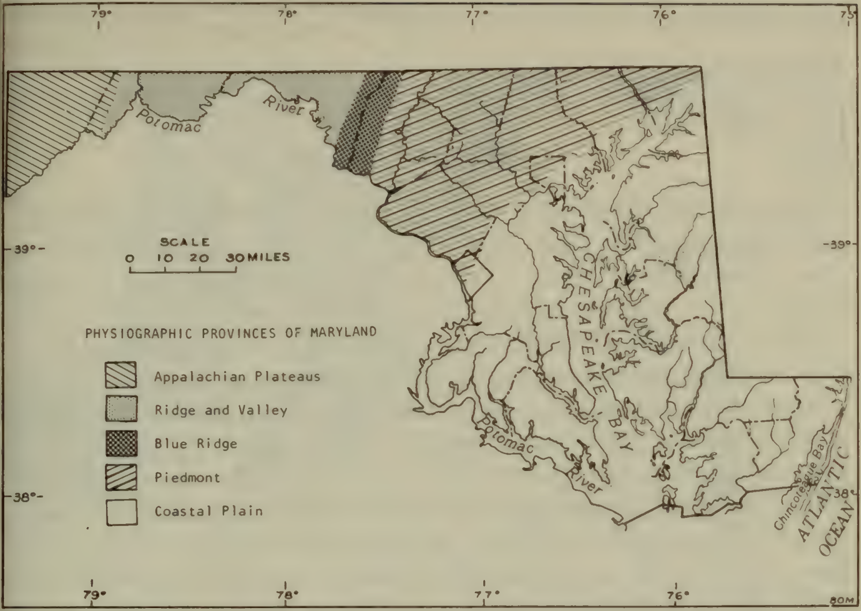

FIGURE 2.—Physiographic provinces of Maryland.

tion. The Oak-Chestnut Forest region is split into a Piedmont section and a Ridge and Valley section, while the Allegheny Mountain section comprises the Mixed Mesophytic Forest region in Maryland.

In general, mammal distribution in Maryland correlates well with these natural areas or sections, and reference is made to them throughout the text. An exception is that of the Upper Chesapeake Bay section (comprising the northern portion of the Eastern Shore, and the Coastal Plain of Baltimore and Harford counties) which seems to be too weakly differentiated as a biotic area from adjacent sections to have any relevance with regard to mammal distribution. This section has been deleted herein, the northern portion of the Eastern Shore being assigned to the Eastern Shore section, and the Coastal Plain of Baltimore and Harford counties being treated as part of the Western Shore section.

The following is primarily a condensation of Stewart and Robbins' description of Maryland's biotic sections.

Eastern Shore Section

The upland forests of this section are composed chiefly of loblolly pine (*Pinus taeda*) stands and oak-hickory forests or a mixture of the two. Along the tidal marshes, loblolly pine is found generally without deciduous associates. The Eastern Shore section is poorly drained and

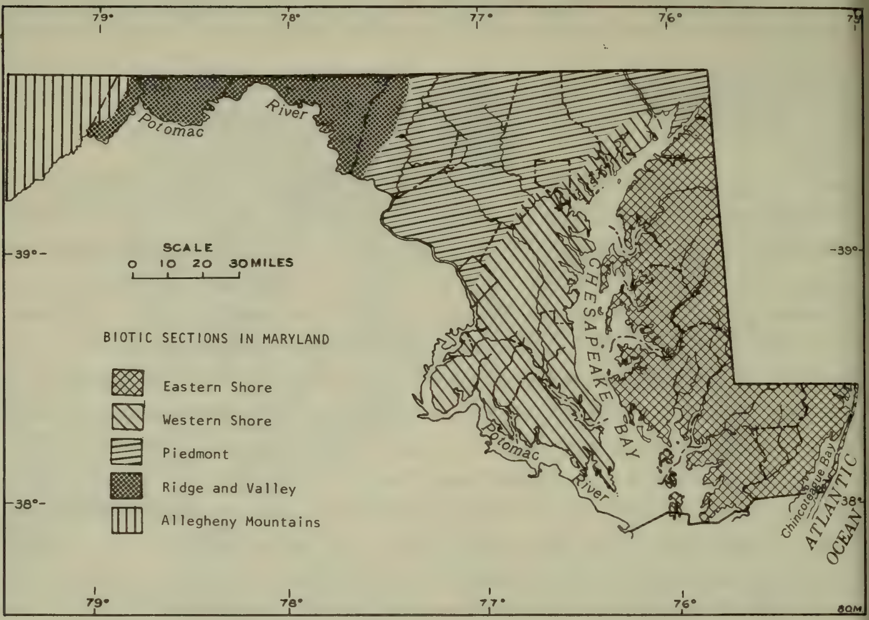

FIGURE 3.—Biotic sections of Maryland.

there are many upland and lowland swamps in which occur sweetgum (*Liquidambar styraciflua*), blackgum (*Nyssa slyvatica*), red maple (*Acer rubrum*), pin oak (*Quercus palustis*), and American holly (*Ilex opaca*). Along the Pocomoke River there are many plants with southern affinities such as bald cypress (*Tacodium distichum*), red bay (*Persea borbonia*), horse-sugar (*Symplocos tinctoria*), water oak (*Quercus nigra*), cross vine (*Bignonia capreolata*), and laurel-leaved greenbriar (*Smilax laurifolia*). In the northern part of this section the upland forests are almost entirely deciduous and of the oak-hickory type. In addition there are such habitats as barrier beaches, salt marshes, and brackish marshes. Elevation is under 100 feet, and the topography is flat.

Western Shore Section

The upland forests of the Western Shore section are composed of scrub pine (*Pinus virginiana*) stands, oak-hickory forests, or a mixture of the two. In the southern part loblolly pine is common, and in the sandy soil of the northern part pitch pine (*Pinus rigida*) frequently predominates. Rich moist upland forests of white oak (*Quercus alba*) and tulip poplar (*Liriodendron tulipifera*) occur locally throughout the section. Small seepage areas are frequent and usually support an upland swamp forest type that contains a well-developed understory. Flood-plain forests are particularly luxuriant in the Western Shore section. Tidal marshes are commonly found around the numerous estuaries. Elevation is from 100 to 300 feet, and the topography is rolling.

Piedmont Section

The Piedmont section occupies the area of the Piedmont physiological province (Fenneman, 1938) and a small part of the Coastal Plain known as Elk Neck in Cecil County. The forests in this section consist mostly of white oak, black oak (*Quercus velutina*), tulip poplar, smoothbarked hickories (*Carya* sp.), and flowering dogwood (*Cornus florida*). In some areas chestnut oak (*Quercus prinus*) or scarlet oak (*Quercus coccinea*) is common, and occasionally stands of scrub pine or pitch pine are found. Beech (*Fagus grandifolia*) is often encountered on ravine slopes, and mixed mesophytic forest communities occur in some of the larger valleys with steep north slopes. These communities contain a mixture of central and northern hardwoods and sometimes hemlock (*Tsuga canadensis*). Elevations in this section range between 300 and 800 feet, and the topography is gently rolling. Much of the land has been cleared for farming.

Ridge and Valley Section

Chestnut oak is the common tree throughout most of the section, and in the higher elevations it is often found in nearly pure stands. In dry areas and on slopes with southern or western exposure there is scarlet oak, interspersed with occasional stands of scrub pine, pitch pine, or Table Mountain pine (*Pinus pungens*). Most of the ravines and steep northern slopes are occupied by mixed mesophytic forest communities in which the common species are hemlock, white pine (*Pinus strobus*), beech, sweet birch (*Betula lenta*), basswood (*Tilia americana*), sugar maple (*Acer saccharum*), tulip poplar, white oak, and northern red oak (*Quercus rubra*). On the valley floors, white oak, black oak, tulip poplar, and flowering dogwood communities occur. Groves of red cedar (*Juniperus virginiana*) are found in the limestone areas of the Hagerstown Valley. The section consists of a series of parallel ridges that range up to 2,000 feet in elevation.

Allegheny Mountain Section

This area is a high, undulating plateau, averaging about 2,500 feet above sea level. Several ridges, some 500 feet high, cross this plateau diagonally from northeast to southwest. The highest point in the State, Backbone Mountain (3,342 feet), is in this section. Hemlock and white pine are occasionally encountered on the slopes and in the valleys, but deciduous trees predominate. These include sweet birch, sugar maple, red maple, black cherry (*Prunus serotina*), basswood, beech, shagbark hickory (*Carya ovata*), white oak, and northern red oak. On higher ridges, northern red oak and red maple predominate, with chestnut oaks, black oak, and yellow birch (*Betula lutea*) interspersed. Scattered red spruce (*Picea rubens*) is sometimes also found. In valleys above 2,400 feet, there are some relict bogs consisting of sedge meadows and bog heaths interspersed with patches of alder (*Alnus* sp.), great laurel (*Rhododendron maximum*), red spruce, hemlock, yellow birch, and red maple.

MARYLAND'S MAMMALIAN FAUNA

These biotic sections of Maryland are not sufficiently differentiated to support widely divergent mammalian populations. Some forms are confined to one or two sections of the State, but in general the mammalian fauna does not differ greatly from section to section. The average-fauna formula (Long, 1963) discussed below, reveals that the most significant division in the State is between the Piedmont section and the Ridge and Valley section. The most diversified mammalian fauna is in the Allegheny Mountain section, the most impoverished in the Eastern Shore section.

Long (1963, p. 139) recommends the average-fauna formula, $2C(100)/(N_1+N_2)$, for deriving a numerical expression of the faunal resemblance of one area to another (in this formula, C=number of kinds common to both faunas, N_1=number of kinds in smaller fauna, N_2=number of kinds in larger fauna). Using this formula, and substituting the number of species and subspecies for each section of Maryland, the following comparisons were obtained:

	Western Shore	Piedmont	Ridge and Valley	Allegheny Mountain
Eastern Shore	90	83	73	62
Western Shore		92	77	67
Piedmont			83	68
Ridge and Valley				87

These percentages show, as is to be expected in an area of this small size, that the mammal fauna of all the sections of Maryland rather closely resemble one another. Naturally, the most distant sections of the State geographically and ecologically, the Allegheny Mountain and the Eastern Shore, differ the most faunistically. Nevertheless 75 percent of the species and subspecies are common to both sections. The losest resemblance between two sections is that between the Western Shore and the Piedmont. Surprisingly, the two Coastal Plain sections, he Western Shore and the Eastern Shore, show slightly less resemblance to each other. This is probably due to the isolating effect of he Chesapeake Bay on the Eastern Shore.

The percentages show clearly that the Allegheny Mountain and Ridge and Valley sections have close faunal resemblance, and that as a unit they stand somewhat apart from the three eastern sections. Thus, while the resemblance ratio of the Eastern Shore to the Western Shore is 90 percent, and that of the Western Shore to the Piedmont is 92 percent, the Piedmont has a resemblance to the neighboring Ridge and Valley section of only 83 percent. The resemblance of the Ridge and Valley to its neighboring Allegheny Mountain section returns to 87 percent, indicating that these two sections differ to some extent from the three eastern sections, which in turn appear to form a closely allied mammalian fauna unit. Therefore, the most strongly marked division with regard to mammal distribution in Maryland is that between the gently rolling Piedmont of Montgomery, Howard, Baltimore, Harford, Carroll, and eastern Frederick Counties and the upland Blue Ridge Mountains (Ridge and Valley section) to the west in Washington and western Frederick Counties.

Taken as a whole, Maryland's mammal fauna seems to be more northern than southern in origin. Only a few distinctly southern species (represented usually by small numbers of individuals) reach Maryland. Some of these are *Reithrodontomys humulis*, *Sorex longirostris*, and *Spilogale putorius*. On the other hand, a number of distinctly northern species reach south to Maryland (*Sorex cinereus*, *Mustela erminea*, *Lepus americanus*, *Tamiasciurus hudsonicus*, and a number of others) and extend even farther south, particularly in the Appalachian Mountains, where many of them range as far south as North Carolina and Tennessee.

KEYS

The following keys employ external and easily observable or measurable characters when possible. In a few instances it has been necessary to resort to dental characters when external ones were not sufficiently marked to separate forms. The keys are designed for use on adult animals only.

Key to the Orders of Maryland Land Mammals

1*a*. Forelimbs modified as wings........................ *Chiroptera* (bats)
b. Forelimbs not modified as wings.................................. 2
2*a*. Feet provided with hoofs........ *Artiodactyla* (even-toed hoofed mammals)
b. Feet provided with claws.. 3

3*a*. Canine teeth absent; incisors chisel-like ---------------------------- 4
b. Canine teeth present; incisors not chisel-like ---------------------- 5
4*a*. Upper incisors 2–2 -------------------- *Lagomorpha* (rabbits, hares, etc.)
b. Upper incisors 1–1 ---------------------- *Rodentia* (gnawing mammals)
5*a*. Canine teeth similar in appearance to other teeth; eyes inconspicuous ---- *Insectivora* (moles, shrews, etc.)
b. Canine teeth well developed; eyes not rudimentary ---------------- 6
6*a*. Tail prehensile; first digit on fore and hind limbs opposable; abdominal pouch present in female -------------- *Marsupialia* (pouched mammals)
b. Tail not prehensile; first digit not opposable; no abdominal pouch present ---------------------------- *Carnivora* (flesh eating mammals)

Key to the Order Insectivora in Maryland

1*a*. Forefeet greatly enlarged and adapted for digging ------------------ 9
b. Forefeet similar in size to hind feet and not adapted for digging ------- 2
2*a*. Tail short, less than 25 percent of total length of animal ------------- 3
b. Tail long, more than 30 percent of total length of animal ------------- 4
3*a*. Coloration grayish; size more than 100 mm.; 32 teeth in mouth *Blarina brevicauda* (short-tailed shrew)
b. Coloration brownish; size small, less than 100 mm.; 30 teeth in mouth *Cryptotis parva* (least shrew)
4*a*. Third and fifth upper unicuspid teeth minute so that only three of the five upper unicuspids are visible when skull is viewed laterally *Microsorex hoyi* (pigmy shrew)
b. Only fifth unicuspid tooth in upper jaw minute so that four unicuspids are visible when skull is viewed laterally ------------------------ 5
5*a*. Total length 145 mm. or more; hind feet large and fringed with stiff hairs; third and fourth toes of hind feet thinly webbed for about half their length -------------------------- *Sorex palustris* (water shrew)
b. Total length 135 mm. or less; hind feet not conspicuously large and not fringed with stiff hairs; no webbing on any toes ----------------- 6
6*a*. Tail more than 55 mm. in length; coloration uniform dark gray throughout -------------------------------- *Sorex dispar* (long-tailed shrew)
b. Tail less than 55 mm. in total length; coloration not uniformly dark gray -- 7
7*a*. Total length greater than 110 mm ----------- *Sorex fumeus* (smoky shrew)
b. Total length under 100 mm ----------------------------------- 8
8*a*. Coloration reddish brown ----------- *Sorex longirostris* (southeastern shrew)
b. Coloration dull brown or grayish brown ----- *Sorex cinereus* (masked shrew)
9*a*. Snout fringed with fleshy projections; tail long, more than 50 mm. in length --------------------------- *Condylura cristata* (star-nosed mole)
b. Snout not fringed with fleshy projections; tail less than 40 mm. in length --- 10
10*a*. Tail thin, flesh-colored and scantily haired *Scalopus aquaticus* (eastern mole)
b. Tail thick, blackish and well haired *Parascalops breweri* (hairy-tailed mole)

Key to the Order Chiroptera in Maryland

1*a*. Interfemoral membrane wholly or partially furred on upper surface ----- 2
b. Interfemoral membrane not furred on upper surface ------------------ 4

2*a*. Coloration reddish-orange------------------ *Lasiurus borealis* (red bat)
b. Coloration brownish to black, frosted with white-------------------- 3
3*a*. Total length greater than 125 mm.; interfemoral membrane wholly furred; coloration brownish, heavily frosted with white; individual hairs banded-------------------------- *Lasiurus cinereus* (hoary bat)
b. Total length less than 120mm.; interfemoral membrane only partially furred; coloration blackish, lightly frosted with white; individual hairs not banded--------------- *Lasionycteris noctivagans* (silver-haired bat)
4*a*. Ears reaching considerably beyond end of nose when laid forward----- 5
b. Ears not reaching noticeably beyond end of nose when laid forward--- 6
5*a*. Ears greatly enlarged, over 35 mm. from crown in length *Plecotus townsendii* (big-eared bat)
b. Ears not noticeably enlarged---------------- *Myotis keenii* (Keen myotis)
6*a*. Over 100 mm. in total length------------- *Eptesicus fuscus* (big brown bat)
b. Under 100 mm. in total length-- 7
7*a*. Under 85 mm. in total length; distinct black facial mask *Myotis subulatus* (small-footed myotis)
b. Over 85 mm. in total length; no black facial mask--------------------- 8
8*a*. Pale golden brown in coloration; nose, ears, and wings reddish-brown *Pipistrellus subflavus* (eastern pipistrelle)
b. Coloration dark brown; ears, nose, and wings nearly black------------- 9
9*a*. Fur long, thick, and shiny------------ *Myotis lucifugus* (little brown bat)
b. Fur short, dull and sparse-- 10
10*a*. Coloration dark brown; ears thick and leathery *Nycticeius humeralis* (evening bat)
b. Coloration pinkish brown; ears not thick and leathery *Myotis sodalis* (Indiana myotis)

Key to the Order Lagomorpha in Maryland

1*a*. Length of hind foot greater than 115 mm (as much as 150 mm. in some specimens); coloration white in winter *Lepus americanus* (showshoe rabbit)
b. Length of hind foot less than 115 mm.; coloration brownish in all seasons-- 2
2*a*. Black on forward edge of ear sharply defined from brown of rest of ear; distinct black patch betweep ears *Sylvilagus transitionalis* (New England cottontail)
b. Black on forward edge of ear not sharply defined; no dark patch between ears-------------- *Sylvilagus floridanus* (eastern cottontail)

Key to the Order Rodentia in Maryland

1*a*. Upper incisors with longitudinal grooves--------------------------- 2
b. Upper incisors without longitudinal grooves------------------------ 5
2*a*. Tail very short, equal to about one-sixth of total length *Synaptomys cooperi* (southern bog lemming)
b. Tail longer than one-sixth of total length------------------------- 3
3*a*. Tail less than one-half of total length *Reithrodontomys humulis* (harvest mouse)
b. Tail greater than one-half of total length------------------------- 4

4*a*. Coloration of sides orange; tail often tipped with white *Napaeozapus insignis* (woodland jumping mouse)

b. Coloration of sides yellowish; tail never tipped with white *Zapus hudsonius* (meadow jumping mouse)

5*a*. Tail bushy---------- 6

b. Tail not bushy---------- 10

6*a*. Fore and hind limbs connected by a loose fold of skin; adapting the animal for gliding-------- *Glaucomys volans* (southern flying squirrel)

b. Fore and hind limbs not connected by a loose fold of skin---------- 7

7*a*. Tail less than one-quarter of the total length-- *Marmota monax* (woodchuck)

b. Tail greater than one-third of the total length---------- 8

8*a*. Coloration reddish-brown above; under 325 mm. in total length *Tamiasciurus hudsonicus* (red squirrel)

b. Coloration not reddish-brown; over 325 mm. in total length---------- 9

9*a*. Coloration of upper parts gray, darker along middle of back; under 550 mm. in total length; upper premolars 2–2 *Sciurus carolinensis* (gray squirrel)

b. Coloration of upper parts variable-grayish, reddish, or buffy, but sides not noticeably paler than back; over 550 mm. in total length; upper premolars 1–1---------- *Sciurus niger* (fox squirrel)

10*a*. Coloration on back reddish, marked with several longitudinal black and white stripes---------- *Tamias striatus* (eastern chipmunk)

b. Back not striped---------- 11

11*a*. Tail flattened horizontally, paddle-like---------- *Castor canadensis* (beaver)

b. Tail not horizontally flattened---------- 12

12*a*. Tail compressed laterally---------- *Ondatra zibethicus* (muskrat)

b. Tail not compressed laterally---------- 13

13*a*. Total length over 325 mm---------- 14

b. Total length less than 275 mm---------- 17

14*a*. Total length over 500 mm.; aquatic in habits-- *Myocastor coypus* (nutria)

b. Total length less than 500 mm---------- 15

15*a*. Tail length equal to, or more than, half total length of animal *Rattus rattus* (black rat)

b. Tail length less than half total length---------- 16

16*a*. Tail well haired, and not conspicuously scaly *Neotoma floridana* (eastern woodrat)

b. Tail scantily haired and noticeably scaly- *Rattus norvegicus* (Norway rat)

17*a*. Tail very short, equal to about one-sixth of total length *Pitymys pinetorum* (pine vole)

b. Tail longer than one-sixth of total length---------- 18

18*a*. Tail only moderately short, equal to about one-third of the total length-- 19

b. Tail longer than one-third of total length---------- 20

19*a*. Back marked with a wide band of dull red from forehead to rump *Clethrionomys gapperi* (red-backed vole)

b. Back dark brown to nearly black-- *Microtus pennsylvanicus* (meadow vole)

20*a*. Line of demarcation between coloration of back and abdomen indistinct; coloration often uniform gray throughout-- *Mus musculus* (house mouse)

b. Sharp line of demarcation between coloration of back and abdomen; abdomen always white---------- 21

21*a*. Total length over 225 mm---------- *Oryzomys palustris* (rice rat)

b. Total length under 200 mm---------- 22

a. Coloration on back chestnut brown *Peromyscus leucopus* (white-footed mouse)
b. Coloration on back grayish brown -- *Peromyscus maniculatus* (deer mouse)

Key to the Order Carnivora in Maryland

a. Coloration black, or black and white ---------- 2
b. Coloration not black ---------- 4
2a. Size large, over 1,200 mm. in total length; tail short and not bushy *Euarctos americanus* (black bear)
b. Under 800 mm. in total length; tail long and bushy ---------- 3
3a. Upper parts marked with no more than two white stripes *Mephitis mephitis* (striped skunk)
b. Upper parts marked with four or more white stripes *Spilogale putorius* (spotted skunk)
4a. Black facial mask; tail ringed ---------- *Procyon lotor* (raccoon)
b. No black facial mask; tail not ringed ---------- 5
5a. Total length under 700 mm ---------- 6
b. Total length over 900 mm ---------- 9
6a. Underparts brown except for white spots on chin and throat *Mustela vison* (mink)
b. Underparts whitish or yellowish ---------- 7
7a. No black tail tip; tail less than one-quarter of total length *Mustela nivalis* (least weasel)
b. Black tail tip; tail more than one-quarter of total length ---------- 8
8a. Black tail tip nearly 50 percent of tail vertebrae length *Mustela erminea* (ermine)
b. Black tail tip 40 percent or less of tail vertebrae length *Mustela frenata* (long-tailed weasel)
9a. Claws retractile; pupils of eyes elliptical; tail short, less than 165 mm *Lynx rufus* (bobcat)
b. Claws not retractile; pupils of eyes not elliptical; tail long, over 300 mm ---------- 10
0a. Toes of fore and hind feet webbed; tail thick and heavy; aquatic in habits ---------- *Lutra canadensis* (otter)
b. Toes not webbed; tail not thick and heavy; not aquatic in habits ---------- 11
1a. Coloration reddish; tail tip white ---------- *Vulpes vulpes* (red fox)
b. Coloration grizzled grayish; no white tail tip ---------- 12
2a. Total length over 1,050 mm ---------- *Canis latrans* (coyote)
b. Total length under 1,050 mm ---------- *Urocyon cinereoargenteus* (gray fox)

Key to the Order Artiodactyla in Maryland

1a. Back brownish, or reddish-olive in coloration, speckled with indistinct white blotches; antlers narrow and standing erect above head; small canine teeth in upper jaws ---------- *Cervus nippon* (Sika deer)
b. Back reddish-brown (summer) or grayish (winter) in coloration, not speckled; antlers heavy, and curving forward over head; no canine teeth present in upper jaws ---------- *Odocoileus virginianus* (Virginia deer)

ACCOUNTS OF SPECIES

Order MARSUPIALIA (pouched mammals)

Family DIDELPHIDAE (opossums)

OPOSSUM

Didelphis marsupialis virginiana Kerr

Didelphis virginiana Kerr, The animal kingdom . . ., p. 193, 1792.

Type locality.—Virginia.

General distribution.—In the eastern United States from Vermont, New York, central Michigan, Wisconsin, and Minnesota, south to central Georgia, Alabama, Mississippi, Louisiana, and Texas.

Distribution in Maryland.—Occurs abundantly in all sections of the State.

Distinguishing characteristics.—Teeth 5/4, 1/1, 3/3, 4/4, = 50; tail naked and prehensile; five toes on each foot, the first on each hind foot clawless and thumblike; outer hair long and coarse, underfur short and soft; general coloration grizzled-grayish.

Measurements.—Three adults from Cabin John, Montgomery County, measure: Total length 780, 737, 795; tail vertebrae 298, 325, 333; hind foot 70, 63, 70; greatest length of skull 117.7, 98.6, 111; zygomatic breadth 63.5, 53.5, 54.7.

Habitat and habits.—The opossum prefers densely forested areas. Llewellyn and Dale (1964, pp. 120–121) found that at the Patuxent Research Center, near Laurel, Prince Georges County, this species was primarily an animal of the low, dense woodland, favoring sections near water. They found that well-drained upland woods were less desirable, and the open cleared or cultivated lands seemed to be of slight value for the opossum. Nevertheless, it will frequently wander into meadows and cultivated fields in search of food. The prehensile tail and opposable first toe on the hind foot make this animal almost as much at home in trees as on the ground.

The opossum apparently does not favor the pine woods and salt marshes along the Atlantic coast. One specimen was taken on the Virginia portion of Assateague Island in the early 1930's, but local residents report that none have been seen there in a number of years.

The species is abundant in the Rock Creek Park area of the District of Columbia, often wandering into nearby regions of the city at night, searching for food and sometimes rummaging in garbage pails in residential areas considerably distant from the wooded areas. One such wanderer recently made his abode in the backyard of a row-house near the center of the city where he remained for many weeks, isiting a nearby porch in the evenings to eat the pet food set out by he owner for her cat.

The opossum is a marsupial, distantly related to such animals as the angaroo and the koala of Australia. It gives birth to live young, but he young are born in a premature condition and are nursed in the ouch or marsupium of the mother. When born, they are naked or rublike in appearance, but the forelimbs are well enough developed o be used for crawling into the pouch. Development is rapid in the ouch, and within 4 to 5 weeks the young are ready to leave for short eriods. Llewellyn and Dale (1964, pp. 118–121) found that in Maryand the opossum begins to breed in early February, and young are ound in the pouch until August. Hartman (1952, p. 73) estimates the estation period as slightly under 13 days. Evidently two litters are roduced during a breeding season, but the first litter accounts for he majority of young. Llewellyn and Dale found that the average umber of young for 57 litters in pouch was 7.74.

The opossum makes its home in almost any shelter where it can be ry and safe from enemies. This may be under sheds or buildings, in rush piles, or in holes in trees. In its eating habits the opossum is as nselective as it is in finding a shelter. Hartman (1952, p. 62) lists he frequency of foods taken in the following order: insects, fruits, nvertebrates (other than insects), mammals, reptiles, grains, birds, nd eggs. It also eats carrion.

Specimens examined.—Montgomery County: Bethesda, 2; Boyds, 1; Cabin John, 3; Plummers Island, 2; no exact locality, 2. *Prince eorges County:* Beltsville, 2; Bladensburg, 1; Branchville, 4; Greenelt, 2; Laurel, 36; Patuxent Research Center, 2; T.B., 1. *District of olumbia:* 25.

Other records and reports.—Opossums have been killed in every Maryland county (LeCompte, 1942).

Remarks.—As noted by Gardner (1950, p. 65), Maryland opossums re indistinguishable from Virginia topotypes of *virginiana.*

Order INSECTIVORA (shrews, moles, etc.)

Family SORICIDAE (shrews)

MASKED SHREW

Sorex cinereus Kerr

This species closely resembles the southeastern shrew (*Sorex longirostris*) and the pigmy shrew (*Microsorex hoyi*). The differences between the masked shrew and these other species are discussed under the species accounts of the other two.

There are two subspecies of *Sorex cinereus* in Maryland. These are:

Sorex cinereus cinereus Kerr

Sorex arcticus cinereus Kerr, The animal kingdom . . ., p. 206, 1792.

Type locality.—Fort Severn, Ontario, Canada.

General distribution.—This is a wide-ranging subspecies, distributed over much of the northern part of North America. In the eastern United States it ranges throughout New England, New York, and western Pennsylvania, and south in the Appalachian Mountains to North Carolina.

Distribution in Maryland.—Ridge and Valley, and Allegheny Mountain sections. (See fig. 4.)

Distinguishing characteristics.—Teeth 3/1, 1/1, 3/1, 3/3, = 32; third unicuspid usually larger than, or equal in size to, fourth unicuspid; size very small; snout elongated and pointed; tail long, slightly less than half the total length of the animal; ears short and hidden in fur; coloration in winter pelage dark brown to almost black on upper parts, lighter brown or grayish on underparts; in summer, coloration is somewhat lighter and more brownish.

Measurements.—An adult female from 9 miles east of Oldtown, Allegany County, measures: Total length 88; tail 40; hind foot 11; ear 7; condylobasal length of skull 15.7; cranial breadth 7.4; interorbital breadth 2.3; maxillary breadth 3.9; crown length of upper toothrow (exclusive of first incisors) 5.4.

Habitat and habits.—This shrew is most common around rocks in moist or damp coniferous or deciduous woods. Sometimes it lives in grassy bogs and swamps, but rarely if ever in dry fields or woods.

The nest is located on or near the surface of the ground, in a cavity under a log, rock, or other object. It is composed mainly of leaves, and in shape resembles a flattened sphere some 3 inches in diameter. In its ramblings this shrew utilizes surface runways that it constructs itself and subterranean runways that have been dug by mice.

The masked shrew is a voracious eater and consumes a wide variety of foods. These include beetles, moths, caterpillars, bugs, flies, crickets, spiders, worms, and the flesh of mice and other shrews. It also eats some vegetable matter such as moss and seeds.

Little is known of the breeding habits of the masked shrew. The breeding season may extend from March to September, and as many as three litters may be produced in a single season. The gestation period is probably about 18 days, and from 4 to 10 young are produced per litter, the usual number being 7. The male stays with the female before and after pregnancy and during the early development of the young. A young shrew is able to shift for itself within 20 to 25 days after its birth.

The shrew is physically strong for its size, but being extremely active it seems to burn itself out at an early age. Its longevity is probably not over 2 years if it is allowed to live its full life span.

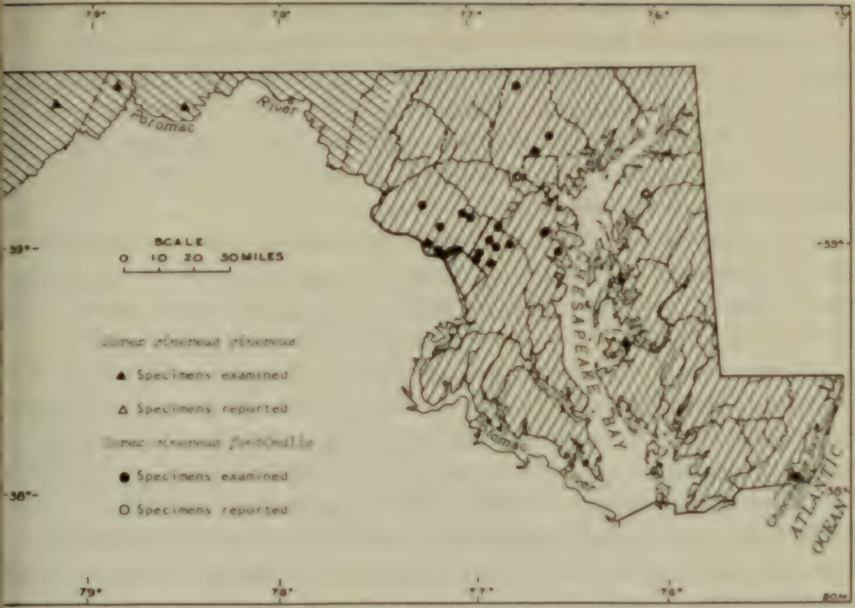

Figure 4.—Distribution of *Sorex cinereus fontinalis* and *S. c. cinereus*.

Specimens examined.—Allegany County: Mount Savage, 1; Oldtown, 3 miles E, 1; Oldtown, 9 miles E, 1. *Garrett County:* Bittinger, 2; Cunningham Swamp, 4 (Coll. U. Md.).

Sorex cinereus fontinalis Hollister

Sorex fontinalis Hollister, Proc. U.S. National Museum, 40: 378, 17 April 1911.

Type locality.—Cold Spring Swamp, near Beltsville, Prince Georges County, Maryland.

General distribution.—Piedmont and Coastal Plain of Pennsylvania, Maryland, and northern Virginia.

Distribution in Maryland.—Piedmont, Western Shore, and Eastern Shore sections.

The characters of this race seem to be best developed in the lower Piedmont section near Washington, D.C. (near the type locality). Specimens from the Coastal Plain sections of the Eastern Shore and upper Western Shore are less typical and apparently represent intergrades with *S. c. cinereus*, which is distributed to the northeast in New Jersey. In the upper Piedmont the subspecies intergrades with *S. c. cinereus*. No specimens of masked shrew have been taken in the southern part of the Western Shore section (Calvert, St. Marys, and Charles Counties) and perhaps the species does not range this far south in the State.

Distinguishing characteristics.—This subspecies is very similar to *S. c. cinereus* and differs from it only in minor details which are most evident on the skull. Externally, the only apparent differences are somewhat smaller size and shorter tail. The skull is smaller, with a narrower braincase and a shorter, relatively wider rostrum. The unicuspid toothrow is shorter than in *S. c. cinereus*, and the teeth in the unicuspid row are more crowded.

This subspecies of masked shrew closely resembles the southeastern shrew (*Sorex longirostris*), which in the eastern United States reaches the northern limits of its range in Maryland. Differences between the two are discussed under the species account for *Sorex longirostris*.

Measurements.—External measurements of eight adults from the vicinity of Rockville, Montgomery County, are as follows: Total length 81.7 (76–89); tail vertebrae 33.7 (30–35); hind foot 10.6 (10–11). Cranial measurements of five adults from the vicinity of Rockville are: Condylobasal length 14.9 (14.7–15.2); cranial breadth 7.0 (6.7–7.1); least interorbital breadth 2.7 (2.6–2.8); maxillary breadth 4.1 (4.0–4.2); crown length of upper toothrow (exclusive of first incisors) 5.5 (5.3–5.7).

Habitat and habits.—Bures (1948, p. 62) collected 14 masked shrews (which he incorrectly believed to be *Sorex longirostris*) near Lake Roland, Baltimore County. He says that, with two exceptions, all of these shrews were taken in a mixed deciduous woods bordering a railroad siding. Of the two exceptions, one was trapped in a dense tangle of sumac and honeysuckle bordering a marsh, and the other in similar habitat along a small stream paralleling Falls Road. He states that systematic trapping throughout the area confirmed his opinion that this shrew does not wander far from deciduous woods. Hampe (1939, p. 5), however, trapped this shrew in the Patapsco State Park in the marshy pastures near Glenartney, and the type specimen of the subspecies was collected in a cold spring swamp in Prince Georges County.

This shrew apparently does not occur on the outer barrier beaches of the Atlantic Coast. Many weeks of trapping there failed to produce a single specimen. It does inhabit the adjacent mainland, and the skull of one was found in an owl pellet on Mills Island in Chincoteague Bay, Worcester County. The shrew had undoubtedly been captured by the owl on the nearby mainland.

Regarding the nesting habits and young of this species, Hampe (1936) writes that he examined the nest of one which was under a discarded trash-filled box among the leaves about 6 feet from the road between Glenartney and Vineyard, Baltimore County. It was composed of a small bundle of dried and broken leaves loosely packed in a small depression in the ground. It was fairly dry, but the surrounding ground was very damp. This nest was found on 18 October 1936

nd contained six blind and hairless young. At the time of this dis-
overy the young were probably a week old, and one of them measured
3 mm. in total length with tail and hind foot measurements of 12 and
mm. respectively. The nest was visited again in about 2 weeks, and
he young had developed to a size of 77 mm. in total length with tail
nd hind foot measurements of 33 and 10 mm. They were well furred
nd quite active. When the nest was visited for the final time on 8 No-
ember, only 3 young could be found, and they quickly scampered
way into the surrounding brush. The mother was seen in the nest only
hen it was first investigated on 18 October, and she scurried away
ery rapidly when the nest was opened.

With regard to feeding and breeding habits of this race not much
s known, but they probably are similar to those of *Sorex c. cinereus.*
As with *cinereus*, this subspecies appears to be cyclical as far as abund-
nce in particular areas is concerned; some years they are scarce, in
thers numerous. An example of how abundant these shrews may be
n some years is provided by Kyle Barbehenn who collected 60 of them
near Germantown, Montgomery County, between November 1958 and
January 1959, and more than 150 near Rockville, Montgomery County,
from February to April 1959.

Specimens examined.—Anne Arundel County: Annapolis, 3 miles NW, 1; Severn Run, 1. *Baltimore County:* Lake Roland, 11; Lock Raven, 5; Pretty Boy Reservoir (near Middletown), 1. *Dorchester County:* Cambridge, 1. *Montgomery County:* Ashton, 1; Bethesda, 1; Cabin John, 1; Chevy Chase, 1; Germantown, 60; Glen Echo Heights, 1; Great Falls, 1; Rockville (near), 153; Sandy Spring, 1. *Prince Georges County:* Beltsville, 1; Bowie, 1; Hollywood, 1; Hyattsville, 5; Landover, 1; Laurel, 3; Patuxent Wildlife Research Center, 3; Tuxedo, 1. *Worcester County:* Mills Island, 1 (from owl pellet).

Other records and reports.—Kent County: Chestertown (U.S. Fish and Wildlife Service files). *Baltimore County:* Patapsco State Park (Hampe, 1936).

Remarks.—This shrew was for many years considered a distinct species. Poole (1937, p. 96), however, showed that in Pennsylvania there is an unbroken gradation between this form and *Sorex cinereus* and that the two are only subspecifically separable. In Maryland, the most typical specimens of *fontinalis* are found in the vicinity of the type locality. Farther to the northwest, near Rockville and Germantown, Montgomery County, specimens, although still referable to *fontinalis*, are somewhat larger than typical of the race, and are approaching *cinereus.* The real dividing line for the 2 subspecies in Maryland is that between the Piedmont and the Ridge and Valley sections, those to the west being referable to *cinereus*, those to the east to *fontinalis.* Specimens from north of Baltimore and from the Eastern Shore section also appear to be intergrading with *S. c. cinereus*. *S. c. fontinalis* appears to represent the end of a cline with regard to small size, shortening of the rostrum, crowding of the unicuspid toothrow, and short tail.

Maryland represents the southern terminus for the distribution of the species *Sorex cinereus* east of the Appalachian Mountains.

SOUTHEASTERN SHREW

Sorex longirostris longirostris Bachman

Sorex longirostris Bachman, Journal Acad. Nat. Science, Philadelphia, ser. 1, 7 (2) : 370, 1837.

Type locality.—Hume Plantations, swamps of the Santee River (= Cat Island, mouth of Santee River), South Carolina.

General distribution.—The southeastern United States from southern Maryland and the District of Columbia to central Florida, and westward, around the southern end of the Appalachian Mountains to Kentucky, central Indiana, and Illinois.

Distribution in Maryland.—The southern portion of the Western Shore section, and perhaps extending into the lower Piedmont section. Maryland is the northernmost limit of the distribution of the species in the eastern United States.

Distinguishing characteristics.—This shrew may be easily confused with *Sorex cinereus*, particularly the race *fontinalis*, and with *Microsorex hoyi*. It is distinguished from *Sorex cinereus* by the following: size smaller; tail shorter; coloration more reddish in winter pelage; feet smaller; rostrum shorter and blunter; unicuspid toothrow more crowded; and a greater tendency for the fourth unicuspid to exceed the third in size. From *Microsorex hoyi* it differs in a major dental character. In *Microsorex* the third upper unicuspid is minute and disk-like, and not visible when the jaw is seen in side view. The fifth unicuspid is also minute and not visible in side view, so that only 3 unicuspids are visible laterally in the upper jaw, the first, second, and fourth. In *Sorex longirostris* (and *Sorex cinereus*) 4 or 5 unicuspids are always visible when the skull is viewed laterally. In addition, *Sorex longirostris* is somewhat larger, more reddish in coloration, and has a longer tail than *Microsorex hoyi*.

Measurements.—One specimen from Chesapeake Beach, Calvert County, has the following cranial measurements: Condylobasal length 14.3; cranial breadth 6.6; least interorbital breadth 2.9; maxillary breadth 4.1; crown length of upper toothrow (exclusive of first incisor) 5.1.

Three specimens from Raleigh, N.C., average 82.6 mm. in total length and have an average tail length of 30.2 mm.

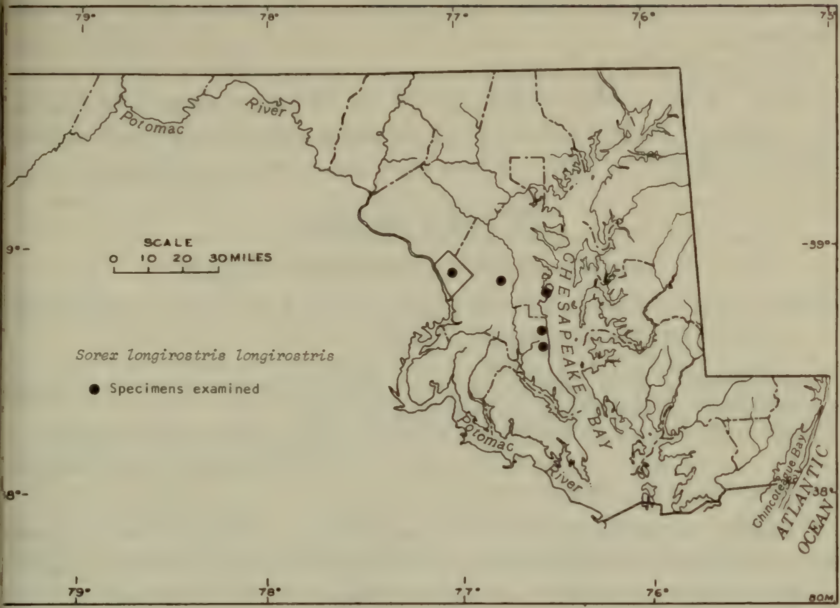

FIGURE 5.—Distribution of *Sorex longirostris longirostris.*

Habitat and habits.—Although this shrew prefers moist situations such as bogs and damp woods, it has on occasion been taken on comparatively high ground. It is a rare species, and little is known of its habits, although they probably do not differ much from those of *S. cinereus.* An interesting sidelight on the specimen from Chesapeake Beach, Calvert County, is a notation on the original label that says "fell over cliffs to bayshore."

Specimens examined.—*Anne Arundel County:* Shadyside, 1. *Calvert County:* Camp Roosevelt, 2; Chesapeake Beach, 1. *Prince Georges County:* Hall, 1. District of Columbia: 1.

Remarks.—It is interesting to note that, in the eastern United States at least, the ranges of *Sorex cinereus* and *Sorex longirostris* do not at present seem to overlap anywhere. North of a certain line (in Maryland this line lies in the Western Shore section between Washington, D.C., and Shadyside, Anne Arundel County) all specimens collected have been *S. cinereus*, whereas south of this line *S. longirostris* only has been taken. There does not appear, however, to be any evidence of intergradation between the species. Specimens of *S. longirostris* from Calvert and Anne Arundel Counties, Md., are just as typical of that species as are those from farther south in North and South Carolina, whereas specimens from Rockville, only a few miles away, are clearly *S. cinereus.* That the two are distinct species is further demonstrated by the fact that both have been taken in the same field in central Indiana.

In all probability *Sorex cinereus* will eventually be found to be a resident of the southern portion of the Western Shore section, and *S. longirostris* may be distributed through more of the Piedmont and northern Western Shore section than is currently indicated.

(WATER SHREW)

Sorex palustris punctulatus Hooper

Sorex palustris punctulatus Hooper, Occas. Papers Mus. Zool. Univ. Mich., 463: 1, 15 September 1942.

Type locality.—West Virginia, Randolph County, 6 miles northwest of Durbin, Shavers Fork of the Cheat River, 3,600 feet elevation.

General distribution.—"Allegheny Mountains of eastern West Virginia, and probably also of southwestern Pennsylvania, western Maryland, and northwestern Virginia." (Hooper, 1942, p. 1).

Distribution in Maryland.—Not recorded for the State, but undoubtedly occurs in the higher elevations of the Allegheny Mountain section.

Distinguishing characteristics.—Largest of all the eastern long-tailed shrews; hind feet large, and with a fringe of stiff hairs; third and fourth hind toes joined by thin web at the base for slightly more than half their length; grizzled coloration on upper parts, and pale gray underparts in winter pelage; tail markedly bicolored. Tooth formula as in *Sorex cinereus*, but third unicuspid smaller than fourth. This is an amphibious species, well adapted for an aquatic life.

Measurements.—Hooper (1942) gives some measurements of the type and two paratypes (from Randolph and Preston Counties, W. Va.) as follows: Total length 152, 153, 155; tail 64, 70, 71; hind foot 19, 20, 20; condylobasal length of skull 21.1, 21.2,——, cranial breadth 10.6, 10.3,——; interorbital breadth 3.9, 3.8, 3.9; maxillary breadth 6.5, 6.4, 6.5; maxillary toothrow 7.9, 8.0, 8.1.

Habitat and habits.—This species prefers very wet areas along the borders of streams, lakes, and ponds. Often it is found in marshes and bogs, and in beaver and muskrat houses, particularly in winter. It favors heavily wooded areas and is rarely found in marshes that are devoid of bushes or trees. According to Hooper (1942), the type specimen of the subspecies *punctulatus* was collected under a log at the base of a yellow birch sapling, in a forest of spruce, hemlock, yellow birch, maple, and beech, about 100 yards from Shavers Fork, the nearest body of water. The paratypes were taken at the edge of streams feeding or draining spruce swamps, one specimen among bracken, rhododendron, and hemlock, the other among sedges, rushes, willow, and spruce. There are many areas similar to this in Garret County ich the water shrew may inhabit, and one of the specimens men- ned by Hooper was taken one mile south-southeast of Cranesville, eston County, W. Va., at an altitude of 2,600 feet, only a few yards m the Maryland State line.

This shrew does not hibernate and is active all winter. It is primarily cturnal in habits, but occasionally is abroad during daylight hours. is well adapted to an aquatic life and is one of the best swimmers of nonmarine mammals. It can swim, dive, float, run along the bottom a pond or creek, and actually run upon the surface of the water for me distance. Jackson (1961, p. 38) says that he once saw a water rew run a distance of more than 5 feet across the surface of a pool. e body and head of the animal were entirely out of the water, the rface tension of the water supporting the shrew, and at each step e animal took there appeared to be a little globule of air held by e hair fringe on the hind feet.

Conaway (1952), writing of the western subspecies *navigator*, says at it apparently has an extensive breeding season since pregnant males have been collected in March, suckling females the first week June, half grown young early in July, a female with five small bryos on August 2, and a male with enlarged testes on 9 August. he number of embryos varies from 4 to 8, and the gestation period probably about 21 days. These shrews do not live long; Conaway timates that the maximum age of any specimen obtained would not in excess of 18 months.

The food of the water shrew consists largely of insect matter, chiefly etles and their larvae, flies, caddisflies, and mayflies. Snails, leeches, all fish, and fish eggs are also consumed. Vegetable matter probably pplies only a small part of the diet.

SMOKY SHREW

Sorex fumeus fumeus Miller

orex fumeus Miller. North American Fauna, 10: 50, 31 December 1895.

Type locality.—Peterboro, Madison County, N.Y.

General distribution.—Eastern North America, from southeastern Ontario d central New England to the Smoky Mountains and northern Georgia. It has so been reported from central Kentucky (Barbour, 1951, p. 102) and south- stern Wisconsin (Jackson, 1928, p. 65).

Distribution in Maryland.—Higher elevations (above 2,000 feet) in e Allegheny Mountain section; may also occur at higher elevations the Ridge and Valley section. It is not a common species in aryland.

Distinguishing characteristics.—In summer pelage resembles *Sorex inereus*, but is larger, has a longer tail, bigger feet, and somewhat

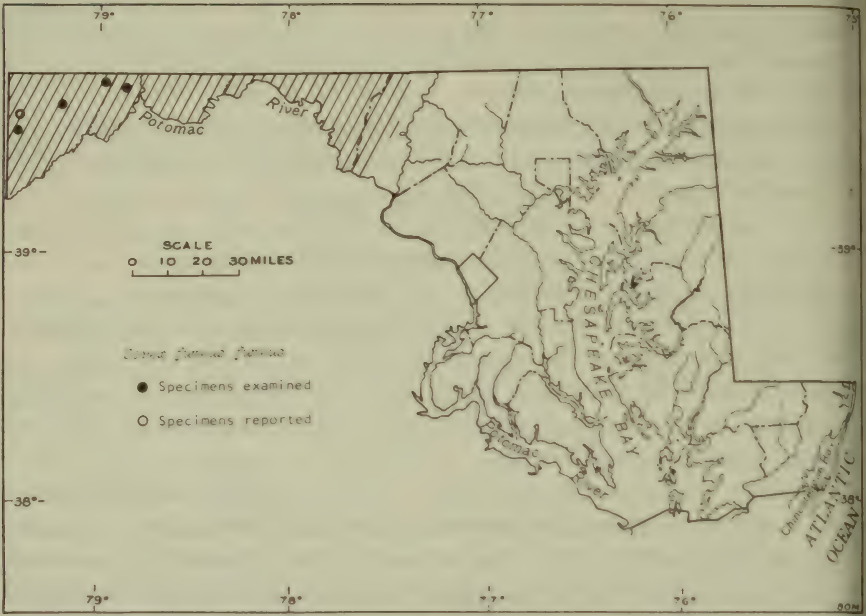

FIGURE 6.—Distribution of *Sorex fumeus fumeus*.

paler coloration. In winter pelage, coloration is grayish, and this shrew resembles *Sorex dispar*, but has a shorter tail. Tooth formula as in *Sorex cinereus*; third unicuspid larger than fourth.

Measurements.—Six adults from Finzel, Garrett County, 6 miles north of Frostburg, average as follows: Total length 110.8 (104–118); tail 44.5 (42–50); hind foot 13.2 (13–14); condylobasal length of skull (average of 3) 17.9 (17.7–18.2); cranial breadth (average of 4) 8.7 (8.6–8.9); least interorbital breadth 3.7 (3.6–3.9); maxillary breadth 5.0 (4.8–5.3); length of maxillary toothrow (average of 5) 6.7 (6.5–6.8).

Habitat and habits.—The smoky shrew is essentially a northern and mountain species and reaches its greatest abundance in the cool forested regions of New England, New York, and Pennsylvania. Most of Maryland apparently does not provide suitable habitat, for it is not a common species in the State. It prefers damp woods and bogs at the higher altitudes, where it lives under moss-covered logs and rocks. E. A. Preble's field notes report that the specimens collected at Finzel were taken in a hemlock and rhododendron swamp, and those at Bittinger, Garrett County, deep in a hemlock forest.

This shrew does not hibernate, and in general is active at all hours of the day and night. Its weak feet are not adapted for digging burrows, and it occupies those made by larger mammals such as the hairy-tailed mole, short-tailed shrew, red-backed mouse, and pine mouse. The ests are located at various places in these tunnels, a favorite being nder a log or stump. These nests, usually made of shredded leaves, are ughly spherical in shape and about the size of a baseball. They gen- rally are situated some 4 to 19 inches below the surface of the ground.

Breeding in this species may begin in late March and the earlier tters appear in early May. As many as three litters may be produced ach season, the last appearing in late August. The gestation period about 20 days, and the young number from 3 to 10, 5 or 6 being e most common.

Hamilton (1940, p. 480) lists the foods of the smoky shrew as the llowing: insects, earthworms, vegetables, centipedes, snails, sala- anders, mammals, sowbugs, spiders, and birds.

Hamilton (1943, p. 486) believes that adults, after completing their productive duties, die of old age when 14 to 17 months of age.

Specimens examined.—Allegany County: Mount Savage, 4 (Coll. . Md.). *Garrett County:* Bittinger, 3; Finzel, 6; Swallow Falls State orest, 3.

Other records and reports.—Garrett County: Cranesville Swamp, ne mile SE (Coll. U. Mich.); Sang Run (Coll. Maryland Nat. Hist. oc.).

LONG-TAILED SHREW

Sorex dispar dispar Batchelder

orex macrurus Batchelder, Proc. Biol. Soc. Washington, 10: 133, 8 December 1896. Not *S. macrourus* Lehmann, 1822.

orex dispar Batchelder, Proc. Biol. Soc. Washington, 24: 97, 15 May 1911. (A renaming of *S. macrurus* Batchelder.)

Type locality.—Beede's (sometimes called Lenne Heights), in township of eene, Essex County, N.Y.

General distribution.—Mountainous regions of the eastern United States, from aine south into North Carolina and Tennessee.

Distribution in Maryland.—Allegheny Mountain section; may occur t higher elevations in Ridge and Valley section. It has been taken in aryland only at Muddy Creek Falls, in Swallow Falls State Forest, arrett County (Mansueti and Flyger, 1952, p. 250). It is one of the rest shrews in Maryland.

Distinguishing characteristics.—Similar to *Sorex fumeus*, but with longer tail, somewhat smaller size, and a uniform slate-gray colora- on in all pelages. Tooth formula as in *Sorex cinereus*, with third nicuspid equal to fourth in size.

Measurements.—External measurements of the type as given in the riginal description are: Total length 130; tail 60; hind foot 15; ear 10.

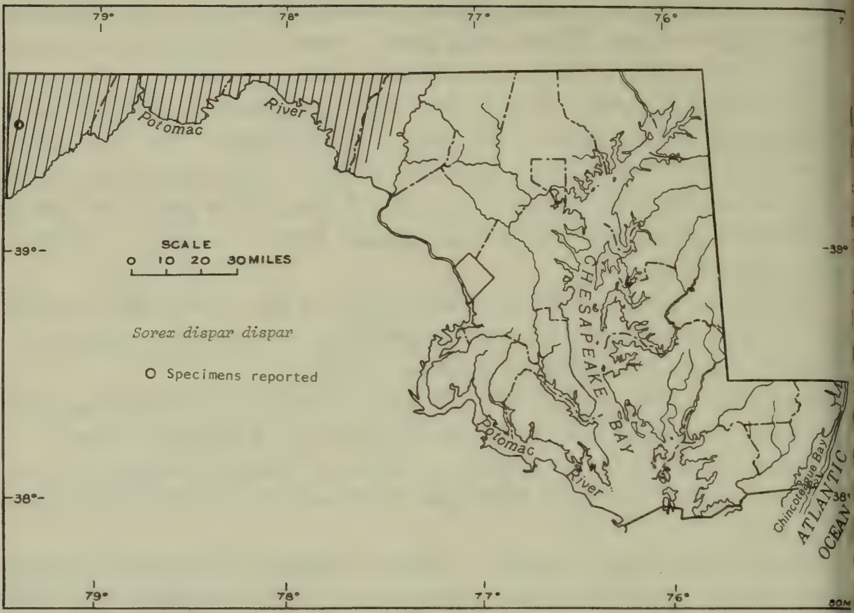

FIGURE 7.—Distribution of *Sorex dispar dispar.*

Some cranial measurements of the type as given by Jackson (1928, p. 90) are: Condylobasal length of skull 18.2; cranial breadth 8.1; interorbital breadth 3.5; maxillary toothrow 6.1.

Habitat and habits.—This shrew prefers moist rocky areas and the crevices between boulders, and large masses of rocks. It has also been taken under moss-covered logs in damp coniferous forests. Mansueti and Flyger (1952, p. 250) report that the three specimens they collected on 6 September 1950, at Muddy Creek Falls, in Swallow Falls State Forest, Garrett County, at an altitude of 2,200 feet, were taken in snap traps placed on ledges in crevices of outcropping sandstone 2 or 3 feet above a small stream's level in a relatively cool moist hemlock and rhododendron forest. Charles O. Handley, Jr. (1956, p. 435) says that the Virginia specimen he took on Big Mountain, Giles County, in September of 1955 was secured in a trap set about 12 inches below the surface in a patch of talus.

Very little is known of the habits of this species, but in all probability it differs little from other long-tailed shrews. Hamilton (1943, p. 39) says that G. H. H. Tate collected a female with 2 embryos in late August in the Adirondack Mountains of New York.

Records and reports.—*Garrett County:* Swallow Falls State Forest, at Muddy Creek Falls (Mansueti and Flyger, 1952).

PIGMY SHREW

Microsorex hoyi winnemana Preble

icrosorex winnemana Preble, Proc. Biol. Soc. Washington, 23: 101, 4 June 1910.

Type locality.—Bank of Potomac River near Stubblefield Falls, Fairfax ounty, Va.

General distribution.—Maryland, south into western North Carolina.

Distribution in Maryland.—May occur in all sections, but is rare. t has been taken in Maryland only at Berwyn, Prince Georges ounty.

Distinguishing characteristics.—This is the smallest mammal in orth America and possibly the smallest in the world with respect to eight. Externally it resembles *Sorex cinereus* and *Sorex longirostris*, ut is smaller and darker (less reddish) and has a shorter tail. Alhough the tooth formula is the same as that of the genus *Sorex*, there re certain peculiarities in the upper unicuspid toothrow which disnguish it. The third upper unicuspid is minute and disklike, comressed anteroposteriorly between the second and fourth unicuspids, nd is not visible when the jaw is viewed laterally. The fifth unicuspid minute and peglike, and is also not visible in side view, so that only hree unicuspids can be seen in the side view of the upper jaw (first,

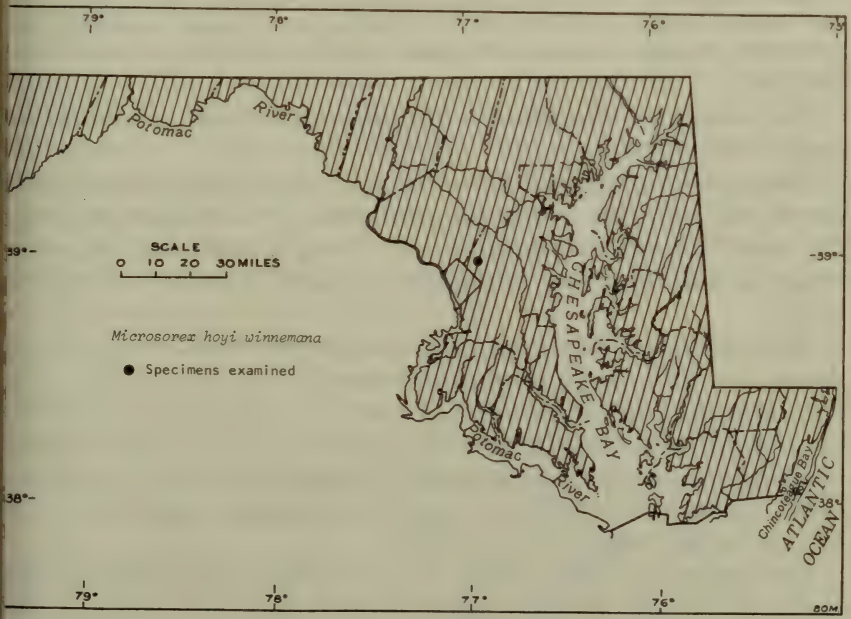

FIGURE 8.—Distribution of *Microsorex hoyi winnemana*.

second, and fourth). This differs from the genus *Sorex* in which fo or five unicuspids are always visible when the skull is viewed laterall

Measurements.—External measurements of the Berwyn specimen a as follows: Total length 86; tail 29; hind foot 9.5. The skull of th specimen is crushed, but some cranial measurements of the type, given by Jackson (1928, p. 210) are: Condylobasal length of sku 13.0; cranial breadth 6.1; interorbital breadth 2.7; maxillary toothro 4.1.

Habitat and habits.—These rare shrews are little known. The ty specimen was dislodged from the decayed interior of a large falle log, and the specimen from Berwyn was found in the decayed hea of a dead chestnut tree, cut from a dry hillside at some distance fro water.

Specimens examined.—Prince Georges County: Berwyn, 1.

SHORT-TAILED SHREW

Blarina brevicauda kirtlandi Bole and Moulthrop

Blarina brevicauda kirtlandi Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist., 5: 99, 11 September 1942.

Type locality.—The Holden Arboretum, Kirtland Township, Lake County, an Chardon Township, Geauga County, Ohio. (The county line bisects the ty locality.)

General distribution.—Ranges from northwestern Michigan, eastern Wisconsi and Illinois, east throughout most of Pennsylvania to central New Jersey an southward through Delaware, Maryland, and West Virginia to southwester Virginia.

Distribution in Maryland.—Abundant in suitable habitat in a sections of the State.

Distinguishing characteristics.—A large, short-tailed, slate-colore shrew, with a shorter blunter muzzle than any of the shrews previous discussed. The tooth formula is as in *Sorex*, with the fifth unicuspi being minute. The teeth are generally darkly tinged with reddis brown.

Measurements.—Thirty-seven adults from the vicinity of Annapoli Anne Arundel County, average as follows: Total length 115.2 (107-122); tail 23.3 (19–27); hind foot 14.4 (13–15). Seventeen adults fro the vicinity of Annapolis have the following cranial measurements Condylobasal length 21.9 (20.8–22.7); mastoidal breadth 12.1 (11.4-12.8); interorbital breadth 5.8 (5.3–6.1); maxillary breadth 7.7 (7.3-8.0); unicuspid toothrow 8.6 (7.9–8.9).

Measurements of eight adults from Cambridge, Dorchester Count (Coll. K.U.), are: Total length 103.6 (101–107); tail vertebrae 23. (20–25.5); hind foot 13.6 (13–14.5); condylobasal length of skull 21.

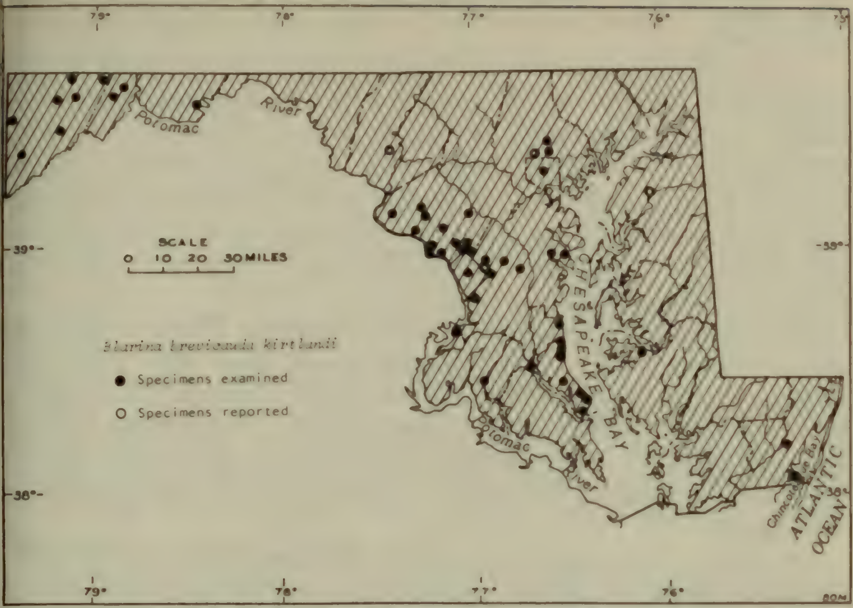

FIGURE 9.—Distribution of *Blarina brevicauda kirtlandi.*

(20.5–21.7); mastoidal breadth 11.3 (11.0–11.7); interorbital breadth 5.4 (5.3–5.6); maxillary breadth 7.3 (7.1–7.6); unicuspid toothrow 7.6 (7.2–8.2).

Habitat and habits.—This is one of the most abundant mammals in Maryland. It is found in a wide variety of habitats, but is most numerous in damp woods where there is a thick understory. It is also encountered in meadows and old fields, but not on the Atlantic barrier beaches of the Delmarva Peninsula, where many weeks of trapping on Assateague Island failed to uncover a single specimen. Elsewhere in the State, this shrew vies with the meadow mouse and the white-footed mouse in abundance, but does appear to be cyclical as regards numbers, and in some years is more plentiful than in others.

The short-tailed shrew, like other Maryland shrews, is active the year around, neither hibernating nor migrating. It is abroad both during daylight hours and at night. It is quick and energetic in its actions, and appears to be constantly on the go during its periods of activity. Its runways zigzag in all directions and lie on the surface of the ground just beneath the vegetation or litter. In these runways, the short-tailed shrew constructs two types of nests. One of these is a small resting nest, and the other a much larger breeding nest. The latter may be some 6 to 10 inches long and averages about 4 inches in diameter. The nests are made of leaves, shredded grasses, and other vegetable fibers. In general, these nests are not as finely made as most mouse nests.

The breeding season for this species extends from March to September, and usually two or three broods of young are reared each season. The gestation period is from 21 to 22 days, and between 3 and 10 young may be produced, although the average number is slightly below 7. These young leave the nest in 18 to 20 days, and by the time they are 3 months of age they are essentially mature animals. This shrew may live up to 3 years, but the life span is usually less than this, probably not more than 18 or 20 months.

This species has a voracious appetite. Hamilton (1930, p. 30) found that an examination of 244 intestinal tracts from New York State *Blarina* yielded the following food percentages: Insects 47.8, arachnids 2, millipedes 1.7, vertebrates 4.1, crustaceans 6.7, mollusks 5.4, annelids 7.2, centipedes 3.8, plant matter 11.4, inorganic matter 2.3, and undeterminable material 5.2. Only 1.7 percent of the stomachs examined were empty.

The bite of this shrew is poisonous. Pearson (1942) found that a poisonous extract could be prepared from the submaxillary salivary glands of this species and that a toxic material is also present in the saliva and may be introduced into wounds made by the teeth, but because of the small size of the animal its bite probably would have little if any effect on man. There have been reports, however, of distress following the bite of a shrew. Maynard (1889) says that when he was bitten by one of them he experienced considerable pain and swelling in the vicinity of the wound which persisted for a week or longer. Others have been bitten repeatedly by shrews of this species and have experienced no after effects whatsoever other than the distress accompanying the actual breaking of the skin by the sharp teeth.

These shrews appear to be somewhat more gregarious than most other species of shrews. It is not uncommon to capture a specimen each night for 4 or 5 consecutive nights in a trap set in the same place, indicating that the animals are using the same runways if not actually associating with each other. It may be stated, however, that in general this shrew is solitary and pugnacious both to its own kind and to any other creature it may encounter.

Specimens examined.—Allegany County: Frostburg, 1 (Coll. Frostburg State College); Mount Savage, 42; Oldtown (near), 7. *Anne Arundel County:* Annapolis (near), 40; South River and U.S. Route 50 (junction of), 1. *Baltimore City:* 1. *Baltimore County:* Dulaney Valley, 1; Loch Raven, 1. *Calvert County:* Breezy Point, 2; Chesapeake Beach, 1; Cypress Swamp along Battle Creek, 2; Hungerford Creek, 3½ miles N of Solomons, 1; Marine Training Base, ¾ mile N of Solomons, 13; Plum Point, 1; Scientist Cliffs, 2; Solomons, 2. *Charles*

County: Benedict, 1; Marshall Hall, 1; Newport, 7. *Dorchester County:* Cambridge, 15 (14 in Coll. K.U.). *Garrett County:* Bittinger, 5; Cranberry Swamp, 1; Finzel, 13; Grantsville, 5; Mountain Lake Park, 2; Swallow Falls State Forest, 2; Swanton, 4; Wolf Swamp, 2. *Montgomery County:* Burnt Mills, 2; Cabin John, 1; Cropley, 2; Germantown, 1; Kensington, 1 mile N, 2; Plummers Island, 3; Poolesville, 1; Rockville, 17; Rockville, 2.3 miles NE, 6; Sandy Spring, 6; Seneca, 3; Sececa Creek at Clopper Road (Route 117), 1; Silver Spring, 6; Takoma Park, 1. *Prince Georges County:* Northwest Branch Anacostia River, 1; Hyattsville, 5; Lanham, 1; Laurel, 4; Mitchellsville, 1 mile W., 2; Oxon Hill, 12; Prince Georges County Sphagnum Bog, 1. *Worcester County:* Mills Island, 2 (skulls from owl pellets); Snow Hill, 5 miles NE, 1. *District of Columbia:* 107.

Other records and reports.—Baltimore County: Lake Roland (Bures, 1948, p. 62); Towson (Gentile, 1949, p. 11). *Frederick County:* Locust Grove (Merriam, 1895, p. 13). *Kent County:* Chestertown (U.S. Fish and Wildlife Service files). *Prince Georges County:* Bladensburg (Bailey, 1896, p. 100).

Remarks.—This species is in need of revision throughout its range. Pending this, only tentative conclusions may be reached regarding the various races and their distribution. At present it appears that three subspecies are distributed along the northeastern coast of the United States. The most northerly race, *talpoides*, ranges throughout most of New England, New York, extreme northern Pennsylvania, and northern New Jersey. It is a large pale race, with an elevated cranium and a long slender rostrum. Distribtued along the east coast to the south of *talpoides* is *kirtlandi* from northeastern Ohio, ranging throughout most of Pennsylvania, central and southern New Jersey, Delaware, Maryland, and West Virginia into southwestern Virginia. It is somewhat smaller and darker than *talpoides* and has a shorter, broader rostrum. Distributed to the south of *kirtlandi* is the very small dark southern race *carolinensis*. Several authorities have considered the range of *carolinensis* to extend north to Cambridge, Dorchester County, Md. (Bole and Moulthrop, 1942, p. 108; Gardner, 1950a, p. 67; Jones and Findley, 1954, p. 210). I have examined a number of specimens from this locality (as well as series from farther south on the Delmarva Peninsula) and consider them to be intergrades between *carolinensis* and *kirtlandi*, but closer to *kirtlandi* and referable to that race. The intergrading character of this population is reflected primarily in smaller size, particularly as regards external measurements. The average total length of eight specimens from Cambridge is 103.6 mm. as contrasted with 97.4 mm. for eight specimens from South Carolina (near the type locality of *carolinensis*) and 116 for the type specimen of *kirtlandi* from northeastern Ohio. Cranially, eight adults from Cambridge average closer in size to *kirtlandi* and have an average condylobasal length of 21.0 and a mastoidal breadth of 11.3, contrasted with an average condylobasal length of 18.4 and mastoidal breadth of 10.1 in typical *carolinensis* (25 specimens from Raleigh, N.C.) and 21.0 and 11.9 in the type specimen of *kirtlandi*. Apparently the entire southern portion of the Delmarva Peninsula is an area of intergradation between *kirtlandi* and *carolinensis*. Specimens I have examined from near Wattsville, Accomack County, Va., and Cape Charles at the southern tip of the Delmarva Peninsula in Northampton County, Va., although still decidedly referable to *kirtlandi*, are smaller in size both externally and cranially than typical *kirtlandi* and appear to be approaching *carolinensis*.

LEAST SHREW

Cryptotis parva (Say)

Sorex parvus Say, in Long, Account of an expedition from Pittsburg to the Rocky Mountains, . . . 1: 163, 1823.

Type locality.—West bank of Missouri River, near Blair, formerly Engineer Cantonment, Washington County, Nebr.

General distribution.—The species is distributed over most of the eastern and midwestern United States, from central New York, Michigan, Wisconsin, Minnesota, and South Dakota, south to Florida in the east, and northeastern Mexico in the west.

Distribution in Maryland.—Occurs in all sections of the State.

Distinguishing characteristics.—Teeth 3/1, 1/1, 2/1, 3/1, = 30; small size; brownish coloration; short tail. Most closely resembles *Blarina brevicauda* but is smaller, more brownish, and has 30 teeth instead of 32. It may be distinguished from all other shrews in Maryland by its short tail.

Measurements.—Six adults from 3/4 mile N of Solomons Island, Calvert County, measury as follows: Total length 76.3 (74–80); tail 15.2 (14–16); hind foot 10(10–11); condylobasal length of skull 15.2 (15.0–15.6); palatal length 6.5 (6.4–6.9); cranial breadth 7.7 (7.6–8.0); interorbital constriction 3.6 (3.5–3.7); maxillary breadth 5.0 (5.0–5.1); molar toothrow 5.4 (5.2–5.6).

Habitat and habits.—Most commonly found in dry fallow fields and stubble in the uplands, and in the marshes in the coastal areas. This shrew appears to be abundant in some places, and scarce or absent in almost identical habitat elsewhere. Along with *Microtus pennsylvanicus*, it is the most frequently taken small mammal on Assateague Island, where it occurs everywhere except on the sparsely vegetated beach dunes. Another area of abundance for the species is the dry fallow fields of southern Maryland. In such a field, three-fourth mile

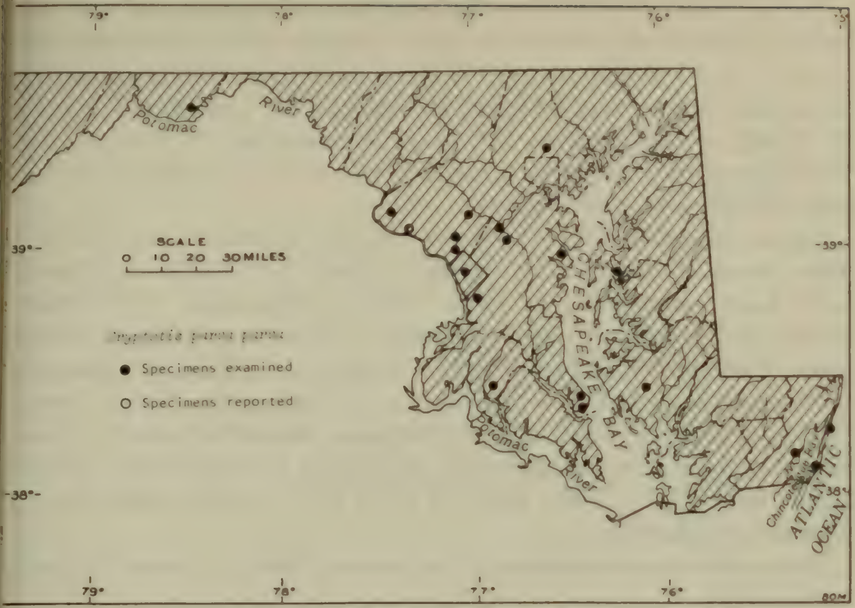

FIGURE 10.—Distribution of *Cryptotis parva parva.*

N of Solomons, Calvert County, this shrew was taken in traps as often as the short-tailed shrew and the house mouse.

This small shrew generally follows the runways of larger mice and shrews, but it also constructs runways of its own. In soft ground it sometimes uses its snout to push dirt away, and by worming its way along may make a tunnel. These small burrows are not much different from those made by certain large beetles or other insects and are difficult to identify. The nest of this species is usually placed in a slight hollow on the surface of the ground, or under a rock or log. Rarely is it located beneath the ground and then only at a depth of 4 or 5 inches or less. Sometimes it will utilize artificial objects such as tin cans in which to nest. The structure of the nest is globular, and composed of dry grass and leaves.

The breeding season for this species is from March to November, and young, born early in the spring, usually breed within the year. The gestation period is about 16 days, and between four and five broods may be produced during a season. The number of young per litter varies from three to nine, with the usual number being four to six.

The food of this species, like that of other shrews, consists primarily of insects and other animal matter. It is known to eat beetles, bugs, grasshoppers, earthworms, millipedes, and snails. It is also said to be fond of salamanders, frogs, and broods of young honeybees.

Unlike most other shrews, the least shrew is gregarious, and may be said to be almost colonial in habits. Jackson (1961, p. 58) says that often when a log, slab, or rock is overturned four to eight or more of these little shrews may be found living together underneath. Maurice K. Brady of Washington, D.C., told Jackson that in Virginia near Washington in 1925 he uncovered a nest of this species which contained 25 *Cryptotis*, all in a pile.

Specimens examined.—Allegany County: Oldtown, 9 miles E, 1. *Anne Arundel County:* Annapolis (vicinity), 2. *Baltimore County:* Lock Raven Reservoir, 1. *Calvert County:* Solomons, 1; Solomons, ¾ mile N, 7. *Charles County:* Newport, 1. *Dorchester County:* Blackwater National Wildlife Refuge, 1. *Montgomery County:* Bethesda, 1; Kensington, 13; Poolesville, 1; Sandy Spring, 19. *Prince Georges County:* Laurel, 6; Oxon Hill, 1; Patuxent Research Center, 5. *Queen Annes County:* Parson Island, 1. *Worcester County:* Ocean City, 4 and 5 miles S, 7; Ocean City, 15 miles S, 1; Chincoteague Bay, 2. *District of Columbia:* 8.

Other records and reports.—Montgomery County: Seneca (Kilham, 1954, p. 252).

Remarks.—This species is in need of revision over its entire range. Until this revision is completed, all specimens from Marvland are provisionally referred to *Cryptotis parva parva.*

Family TALPIDAE (moles)

HAIRY-TAILED MOLE

Parascalops breweri (Bachman)

Scalops breweri Bachman, Boston Jour. Nat. Hist., 4: 32, 1842.

Type locality.—Martha's Vineyard, Massachusetts (there is some question, however, whether this species ever occurred on Martha's Vineyard Island).

General distribution.—Northeastern United States and adjacent Canada, south in the Appalachians to western North Carolina.

Distribution in Maryland.—Occurs at higher elevations in the Allegheny Mountain and Ridge and Valley sections.

Distinguishing characteristics.—Teeth 3/3, 1/1, 4/4, 3/3, = 44; tail short and hairy; coloration dark slate to black dorsally, slightly paler below; pelage soft and thick, but somewhat coarser than in the eastern mole (*Scalopus aquaticus*); palms enlarged and nearly circular in outline; toes not webbed.

This species can readily be distinguished from the eastern mole by its hairy tail, and from the star-nosed mole (*Condylura cristata*) by the absence of nasal projections.

Measurements.—Jackson (1915: 80) gives external measurements of eight males from Magnetic City, N.C., as follows: Total length 149.5

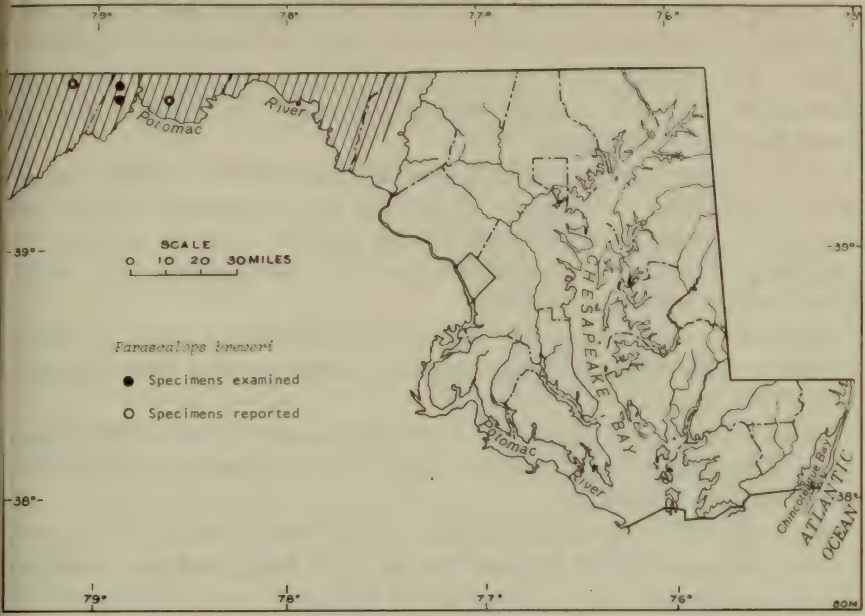

Figure 11.—Distribution of *Parascalops breweri*.

(139–152); tail vertebrae 30 (23–36); hind foot 19.5 (18–20). He gives some measurements of the skulls of 10 adult males from Magnetic City as follows: Greatest length 32.4 (31–33.8); mastoidal breadth 14.5 (13.9–15); interorbital breadth 7.3 (7.1–7.5); maxillary toothrow 9.9 (9.2–10.2). Females average smaller than males.

A male (probably immature) from Vale Summit Road, between Clarysville and Vale Summit, Allegany County, has the following external measurements: total length 136; tail 22; hind foot 16. This animal weighed 35.7 grams.

Habitat and habits.—In Maryland this mole is found only at high elevations in the western part of the State, where it lives in loose well-drained light soils. It may be found in pastureland, as well as in the deep woods, but is seldom encountered in damp areas or in clay soils. Although the eastern mole (*Scalopus aquaticus*) also occurs in western Maryland, it appears to be ecologically or at least altitudinally separated from the hairy-tailed mole. The eastern mole has been taken in the lowlands; the hairy-tail only at higher elevations.

This species makes irregular subsurface runways which form an elaborate network. In the winter these tunnels are deep so as to avoid the freezing temperatures of the upper layers of earth. Nests are constructed in these deep burrows, some 10 to 20 inches below the surface of the ground. These are made of dried grasses and leaves, and are some 6 inches in circumference.

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Mating occurs in March or April, and four to five young are produced in late April or May after a gestation period of probably a month. The young moles develop rapidly and are able to shift for themselves within a month. They are sexually mature and able to breed the following spring.

The primary foods of this species are earthworms, insects, insect larvae, and other arthropods. They are very voracious eaters, and Hamilton (1943, p. 27) reports that a captive mole of this species weighing 50 grams consumed 66 grams of earthworms and insect larvae within a 24-hour period.

Specimens examined.—Allegany County: Mount Savage, 1. (Coll. U. Md.); Vale Summit Road, between Clarysville and Vale Summit, 1 (Coll. U. Md.).

Other records and reports.—Allegany County: Warrior Mountain (U.S. Fish and Wildlife Service files). *Garrett County:* Grantsville, near (Coll. U. Mich.).

Remarks.—Two specimens of this species from Grantsville, Garrett County, collected 28–29 August 1949 by J. A. King, and now stored in the Museum of Zoology, University of Michigan, are the first actually taken in this State. The species, however, is probably not as rare in western Maryland as the few trapping records and reports would indicate.

EASTERN MOLE

Scalopus aquaticus aquaticus (Linnaeus)

(*Sorex*) *aquaticus* Linnaeus, Syst. Nat., ed. 10, 1: 53, 1758.

Type locality.—Philadelphia, Pa. (Fixed by Jackson, N. Amer. Fauna 38, p. 33, 30 September 1915).

General distribution.—Eastern United States, from southern New England, and New York State, south to Virginia, and in the Appalachian Mountains south to Tennessee, North Carolina, and South Carolina.

Distribution in Maryland.—Eastern Shore, Western Shore, and Piedmont sections and at lower elevations in the Ridge and Valley and Allegheny Mountain sections. Rare or absent apparently in the Ridge and Valley, and Allegheny Mountain sections at elevations over 2,000 feet.

Distinguishing characteristics.—Teeth 3/2, 1/0, 3/3, 3/3, = 36; forefeet broad and greatly enlarged, adapted for digging; body stout and cyclindrical; pelage soft and velvety, black to brownish black in coloration; tail short and naked; eyes and ears small and not visible on superficial examination.

Differs from the hairy-tailed mole (*Parascalops breweri*) in that the tail is short and naked, and from the star-nosed mole (*Condylura cristata*) in that the snout is without fleshy projections.

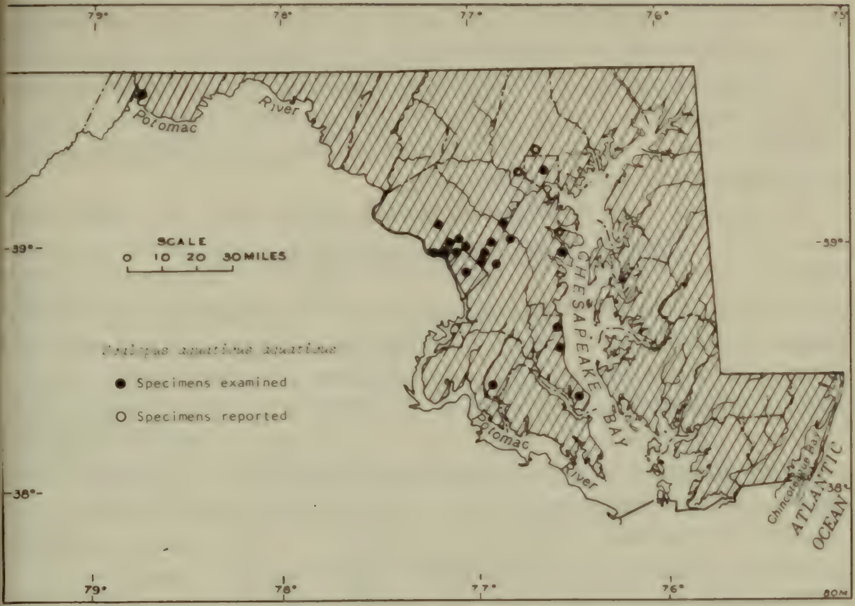

FIGURE 12.—Distribution of *Scalopus aquaticus aquaticus.*

Measurements.—Jackson (1915, p. 34) gives external measurements of 15 adult males from Washington, D.C., as follows: Total length 163.4 (154–175); tail vertebrae 26.5 (22–29); hind foot 19.8 (18–21).

Cranial measurements for 21 adult males from Washington and vicinity are: Greatest length 34.3 (33.2–35.6); mastoidal breadth 17.7 (17–18.3); interorbital breadth 7.4 (7.2–7.8); maxillary toothrow 10.8 (10.4–11.3). Females average smaller than males in size.

Habitat and habits.—The eastern mole normally lives in sandy soils and light loams in meadows, pastures, cultivated fields, gardens, lawns, and thin woods. Rocky areas and swamps are generally avoided since they are barriers to the mole's burrowing activity. It does, however, prefer moist situations to dry ones. Very sandy regions, such as the barrier beaches that line Maryland's ocean front, are apparently unfavorable to the eastern mole, and many weeks of searching for their signs near Ocean City, Worcester County, and on Assateague Island to the south proved fruitless. Bures (1948, pp. 61–62), found moles in the Bare Hills–Lake Roland area of Baltimore County to be restricted to the moist or wet soil bordering the Lake and along the two streams that empty into Jones' Falls. He says that numerous individuals were observed at work on the lawns of property fronting Falls Road. In the Ridge and Valley and Allegheny Mountain sections, there is evidence that this species occurs only in the lowlands, whereas higher up on the mountains it is replaced by the hairy-tailed mole. In Mason County, W. Va., McKeever et al. (1952, p. 25) found an eastern mole inhabiting the sandy soil of the Ohio River bottomland and a hairy-tailed mole in the nearby forest-covered hills. This distribution occurs in the Appalachians in general, including the Ridge and Valley and Allegheny Mountain sections of Maryland.

The eastern mole does not hibernate, but is active the year round. It constructs a series of burrows just beneath the surface of the ground during wet weather to facilitate the capture of earthworms which form a major part of its diet. In dry and cold weather this species digs deeper permanent burrows some 10 or more inches below the surface. Rarely does the eastern mole emerge from its subterranean burrows and prowl about above ground. A nest is built in one of the permanent burrows, which may be from 5 to 18 inches down, usually under the roots of shrubs or stumps. It is most often made from grass and rootlets, but occasionally leaves are employed. This nest is placed on the bottom of a flattened ellipsoidal enlargement of the tunnel, the length of which is about 8 inches and the diameter about 5.

Mating in this species takes place in March and continues into April. The young are born in the latter part of April or in May. The gestation period is about 45 days, and from two to five young are born each season. By the time a young mole is 5 weeks of age it is more than half the size of the mother.

Eighty percent of the diet of the eastern mole is animal matter, consisting primarily of worms, insects, and insect larvae. Some of the favorite foods are beetles, earthworms, wireworms, white grubs, spiders, centipedes, millipedes, slugs, and insect and mollusk eggs. Some of the plant matter consumed are corn, potatoes, grass, tomatoes, apples and occasionally wheat and oats. The eastern mole is a voracious eater and in 24 hours may consume a quantity of food equal to its weight.

> Moles are harmful when they disfigure lawns and provide highways in gardens for field and pine mice. Their destruction of insects places them in a more favorable light. A friend once told me that these moles had almost eliminated the larvae of Japanese beetles on his grounds. Tunneling activities of moles aid in the formation of soil. (Hamilton, 1943, pp. 23–24).

Specimens examined.—Allegany County: Cumberland, 3 (Coll. U. Md.). *Anne Arundel County:* Annapolis, 3 miles NW, 1; no exact locality, 2. *Baltimore City:* 2. *Calvert County:* Chesapeake Beach, 1; Plum Point, 1; Solomons, 4 miles N, 1. *Charles County:* Newport, 3. *Howard County:* no exact locality, 1 (embryo in alcohol). *Montgomery County:* Cabin John, 2; Capitol View, 1; Chevy Chase, 1; Plummers Island, 5; Rockville, 2; Seven Locks, 1; Silver Spring, 4; Woodside, 4. *Prince Georges County:* Beltsville, 2; Berwyn, 1; Branchville,

; Brookland, 1; Highland, 1; Landover, 2; Laurel, 13; Mount Rainier, ; Patuxent Research Center, 1. *District of Columbia:* 83.

Other records and reports.—Anne Arundel County: Severna Park (Cooper, 1953, p. 79). *Baltimore County:* Lake Roland (Bures, 1948, . 61); Patapsco State Park (Hampe, 1939, p. 5). *Montgomery ounty:* Forest Glen (Bailey, 1896, p. 100).

STAR-NOSED MOLE

Condylura cristata cristata (Linnaeus)

(*Sorex*) *cristatus* Linnaeus, Syst. nat., ed. 10, 1: 53, 1758.

Type locality.—Eastern Pennsylvania.

General distribution.—Southeastern Canada, and northeastern United States, outh to central Minnesota, Wisconsin, Indiana, Ohio, eastern West Virginia, nd northern Virginia.

Distribution in Maryland.—Locally abundant in all sections of the State although apparently rare or absent in some areas with suitable habitat.

Distinguishing characteristics.—Teeth 3/3, 1/1, 4/4, 3/3, = 44; body orm mole-like, but more slender; forefeet broad and enlarged for ligging, but not to the same extent as in *Scalopus;* pelage black in oloration, somewhat harsher in texture than that of *Scalopus;* tail ong, and at certain times of the year enlarged. The most distinctive eature of this mole is the snout, which is fringed with 22 pink proections, or tentacles, and is responsible for the popular name of the nimal.

Measurements.—Two adults from the District of Columbia measure as follows: Total length 183, 185; tail vertebrae 65, 66; hind foot 28, 28; greatest length of skull 33.9, 33.4; mastoidal breadth 12.8, 12.8; interorbital breadth 6.8, 6.7; maxillary toothrow 6.6, 6.3.

Habitat and habits.—The star-nosed mole prefers damp habitat in meadows, fields, woods, or swamps, but is sometimes taken in the leaf mold of dense forests, or in relatively dry fields in which there are a few damp spots from which its tunnels radiate. Occasionally it is found at a considerable distance from any water. One specimen was captured in June 1958 in the lower Eastern Shore section near Wattsville, Accomack County, Va., a few miles from the Maryland boundary. It was taken in a museum special mouse trap set in a surface runway in dry meadow at least a fourth of a mile from the nearest water. Generally, however, the star-nosed mole will be encountered in very wet situations, and its tunnels frequently lead directly into a stream or pool. This animal is an efficient swimmer, using its broad forefeet as oars and its tail as a scull.

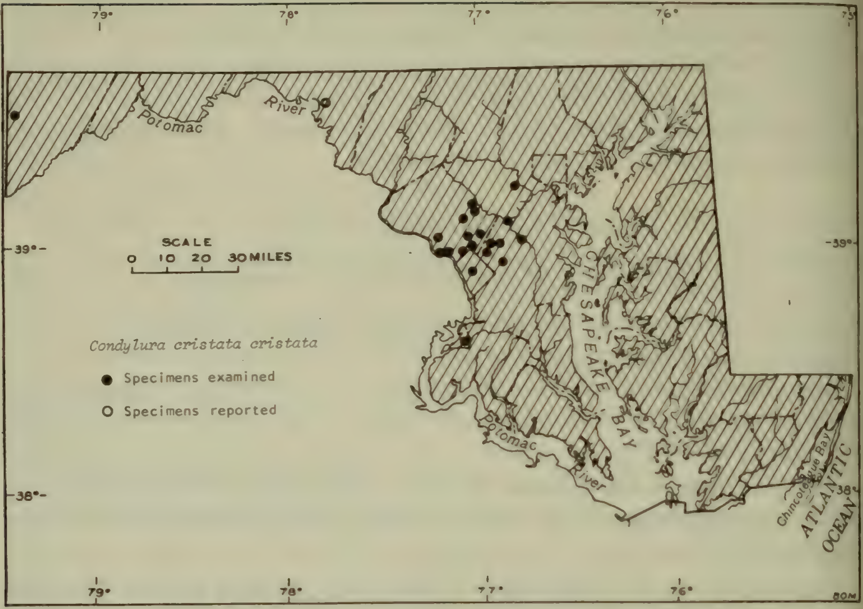

Figure 13.—Distribution of *Condylura cristata cristata*.

The star-nosed mole is less fossorial than the eastern or hairy-tailed moles; it is active both day and night, summer and winter. It often uses surface runways, and sometimes in the winter it will burrow in the snow, or even run across it. The tunnels that this species digs are more irregular in pattern than those of other Maryland moles. These burrows are deep in places, and then abruptly rise to near the surface. Frequently the tunnels enter the bank of a stream a foot or more below the water line. The nest of the star-nosed mole is constructed of leaves and grass and is located in a flattened spherical chamber about 5 or 6 inches in diameter and some 4 or 5 inches high. It is usually placed 3 or 4 inches below the surface of the ground, but may be as much as 10 inches down. It is always, however, above the high water level.

It is believed that star-nosed moles pair in the autumn and remain together until the young are born. Breeding occurs in the spring, and birth is from April to June, the gestation period being about 45 days. There is only a single litter per year, and the size of the litter varies from three to seven, six being the usual number. The young mature rapidly and are ready to leave the nest within about a month's time. Star-nosed moles are more gregarious than other eastern moles, and may perhaps, be colonial, although colonies are probably formed through family lineage.

Star-nosed moles are amphibious, and spend a good deal of time in water. They are excellent swimmers and divers, and a large portion of their food consists of aquatic insects and worms, only about one fourth of the diet being composed of terrestrial forms.

Specimens examined.—Charles County: Marshall Hall, 1. *Garrett County:* Cranesville Swamp, 1. *Howard County:* Ellicott City, 1. *Montgomery County:* Brookeville, 1; Burnt Mills, 1; Cabin John, 1; Chevy Chase, 1; Chevy Chase Lake, 1; Oakdale, 1; Plummers Island, 1; Potomac P.O., 1; Sandy Spring, 1; Silver Spring, 1; Woodside, 2. *Prince Georges County:* Beltsville, 1; College Park, 2; Glenndale, 1; Lanham, 1; Laurel, 2; Patuxent River Marsh, 1; no exact locality, 1. *District of Columbia:* 10.

Other records and reports.—Prince Georges County: Branchville (U.S. Fish and Wildlife Service files). *Washington County:* Williamsport (Jackson, 1915, p. 91).

Remarks.—Maryland specimens average somewhat smaller in size, both externally and cranially than typical *C. c. cristata*, and are tending in this character toward the smaller southern subspecies *C. c. parva.*

Order CHIROPTERA (bats)

Family VESPERTILIONIDAE (vespertilionid bats)

LITTLE BROWN MYOTIS

Myotis lucifugus lucifugus (Le Conte)

V[*espertilio*]. *lucifugus* Le Conte, *in* McMurtrie, The animal kingdom . . . by the Baron Cuvier, vol. 1, App., p. 431, 1831.

Type locality.—Georgia; probably the Le Conte plantation near Riceboro, Liberty County.

General distribution.—Eastern and northern North American from Alaska and Labrador south in the Appalachians to Georgia, and west into Arkansas.

Distribution in Maryland.—Abundant in all sections of the State.

Distinguishing characteristics.—Teeth 2/3, 1/1, 3/3, 3/3, = 38; face covered with fur except for lips and nostrils; ears moderately long, not extending beyond nostrils when laid forward; tragus slender and pointed; wing membrane between humerus and knee sparsely furred; interfemoral membrane not furred; coloration rich brown, almost bronze; young animals much darker in coloration; sagittal crest usually lacking on skull.

Measurements.—Eight adults from the District of Columbia have external measurements as follows: Total length 85.6 (80–95); tail vertebrae 38.5 (36–42); hind foot 8.9 (8.0–10.5). Some cranial measurements of seven adults from Washington, D.C., are as follows:

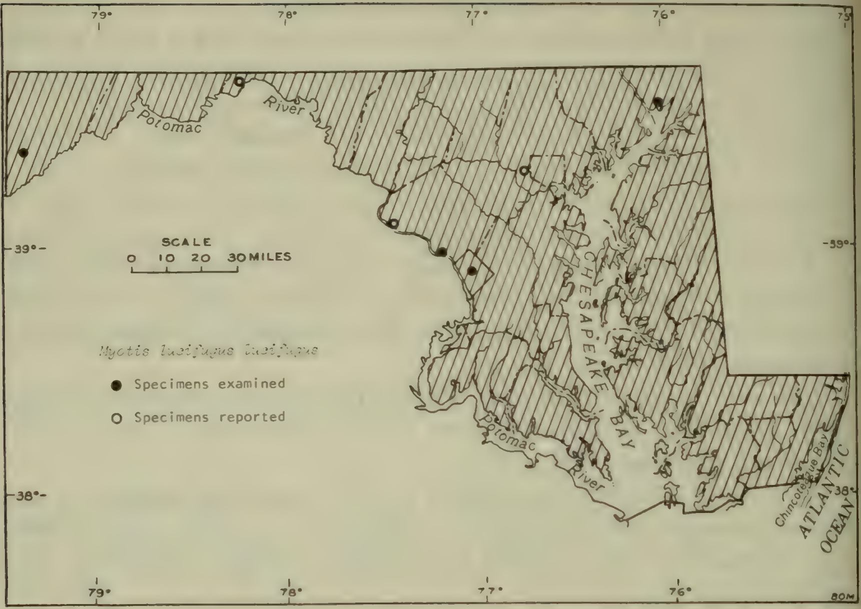

Figure 14.—Distribution of *Myotis lucifugus lucifugus.*

Greatest length 14.0 (13.7–14.2); zygomatic breadth 8.4 (8.0–9.1); interorbital breadth 4.0 (3.9–4.2); length of maxillary toothrow 5.1 (5.0–5.2).

Habitat and habits.—This species occurs almost everywhere, roosting in the attics of houses, in hollow trees, or in caves. It is gregarious by nature; in the attic of one house near Seneca Point, Cecil County, over 9,000 were found roosting at one time.

The little brown myotis hibernates in winter and, in some areas at least, is migratory in habits, traveling "flyway" routes from winter hibernating quarters to summering areas. During these migrations they may travel as far as 100 to 150 miles or more, returning by similar routes to their winter quarters. The migratory patterns of Maryland's little brown myotis have not been studied, but the files of the Bat Banding Office, U.S. Fish and Wildlife Service, contain two records of movements of this species into the State. In both instances, the little brown myotis were banded in Hellhole Cave, Pendleton County, W. Va., in March 1964 and were picked up in the vicinity of Deep Creek Lake in Garrett County in June and July of 1964. Perhaps some of Maryland's *Myotis lucifugus* population winters in caves in West Virginia and Virginia, and travels north to forage in Maryland during the summer. Others that winter in Maryland may venture further north into Pennsylvania in the summer months.

Mating in this species usually occurs in the autumn, before the bats enter hibernation. Normally the spermatozoa survive in the uterus throughout the winter, and fertilization occurs the following spring. Copulation, however, may occur during the winter or in the spring. The gestation period probably is about 80 days, and the young are born in late May or early June. Usually only a single offspring comprises a litter, but occasionally two are produced. In about 4 weeks after their birth, the young are flying and foraging for their own food. Sexual maturity is achieved at about 8 months. There is only one litter per season.

The food of the little brown myotis appears to be composed entirely of insects, particularly nocturnal species of moths, beetles, and bugs. It has a voracious appetite, consuming large numbers of insects nightly.

This bat is long-lived; there are records of banded animals recovered in good health as much as 20 years after banding.

Specimens examined.—Cecil County: Seneca Point, 1. *Garrett County*: Oakland, 1. *Montgomery County*: Plummers Island, 1. *District of Columbia*: 29.

Other records and reports.—Baltimore County: Patapsco State Park (Bull. Nat. Hist. Soc. Maryland 10 (1), p. 5, 1939). *Garrett County:* Deep Creek Lake (banding recovery record). *Montgomery County:* Edwards Ferry (banding recovery record). *Washington County:* Round Top Mountain, near Hancock (banding record).

Remarks.—This bat is far more common than the few locality records above would indicate. It is probably the most abundant bat in Maryland.

KEEN'S MYOTIS

Myotis keenii septentrionalis (Trouessart)

[*Vespertilio gryphus*] var. *septentrionalis* Trouessart, Catalogus mammalium . . . , fasc. 1, p. 131, 1897.

Type locality.—Halifax, Nova Scotia, Canada.

General distribution.—Eastern North America, from Newfoundland, Nova Scotia, Quebce, and Ontario, south to northern Florida and west to Manitoba, North and South Dakota, Nebraska, Kansas, and Arkansas.

Distribution in Maryland.—Occurs in all sections of the State, and is common.

Distinguishing characteristics.—This bat is similar in size and color to the little brown myotis (*Myotis lucifugus*), but may be distinguished from that species by its long ears, which extend some 4 to 5 millimeters beyond the tip of the nose when laid forward. The skull is narrower in proportion to its length than that of the little brown myotis.

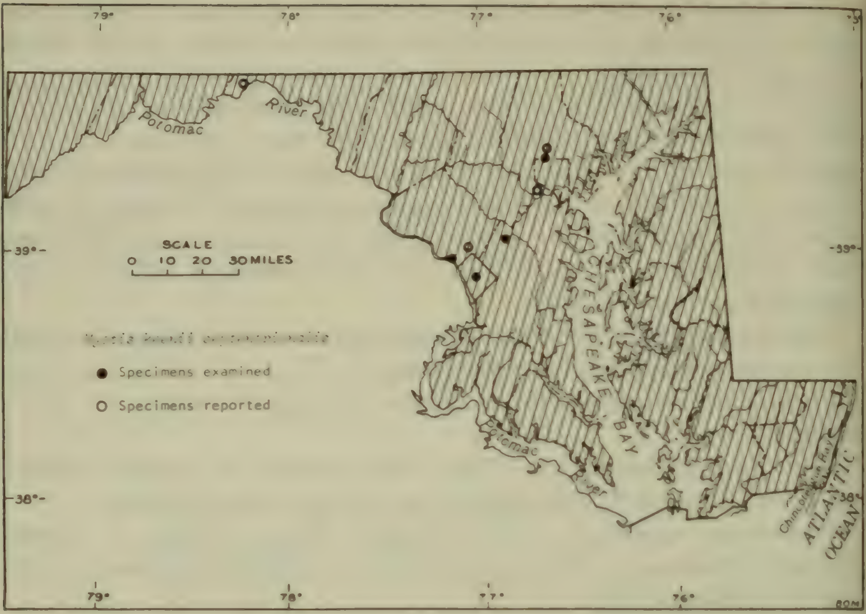

FIGURE 15.—Distribution of *Myotis keenii septentrionalis.*

Measurements.—External measurements of three adults from Plummers Island, Montgomery County, are as follows: Total length 81, 87, 75; tail vertebrae 38, 35, 35; hind foot 9, 9, 10. Some cranial measurements of four adults from Plummers Island are: Greatest length 14.5 (14.4–14.7); zygomatic breadth 8.9 (8.8–9.0); interorbital breadth 3.6 (3.6–3.7); length of maxillary toothrow 5.9 (5.7–6.0).

Habitat and habits.—This species roosts in small colonies in caves, and under loose bark on trees. Frequently it is found in association with the little brown myotis, from which it differs little in habitat selection or habits, except that it seems to be more solitary. Mansueti (1941, pp. 56–57) found one sleeping under the bark of a dead standing tree near Arbutus, Baltimore County. When he peeled the bark away, the bat flew to a nearby tree and crawled up under some loose bark on it. This species is more abundant than the few Maryland records indicate.

Specimens examined.—*Baltimore County:* Bare Hills, 1. *Montgomery County:* Cabin John Bridge, 1; Plummers Island, 5. *Prince Georges County:* Muirkirk, 1. *District of Columbia:* 4.

Other records and reports.—*Baltimore County:* Arbutus (Mansueti, 1941); Lake Roland (Bures, 1948: 63). *Montgomery County:* Forest Glen (Miller, 1897: 76). *Washington County:* Round Top Mountain, near Hancock (bat banding record, U.S. Fish and Wildlife Service).

INDIANA MYOTIS

Myotis sodalis Miller and G. M. Allen

yotis sodalis Miller and G. M. Allen, Bull. U.S. Nat. Mus., 144: 30, 25 May 1928.

Type locality.—Wyandotte Cave, Crawford County, Indiana.

General distribution.—Eastern United States from central New England west Wisconsin, Missouri, and Arkansas, south into northern Florida. It occurs the Atlantic Coastal Plain, however, only in the New England area.

Distribution in Maryland.—Apparently very rare in the State. Its istribution is probably limited to limestone caves in the Ridge and alley and Allegheny Mountain sections.

Distinguishing characteristics.—Resembles *Myotis lucifugus*, but iffers in coloration, the fur being a dull grayish chestnut rather an bronze, with the basal portion of the hairs of the back dull lead olored; coloration of underparts pinkish to cinnamon; hind feet naller and more delicate than in *M. lucifugus*; slight, but well-dened sagittal crest usually present on skull.

Measurements.—Two adults from the type locality in Indiana have easurements as follows: Total length 86, 87; tail vertebrae 35, 38; ind foot 9, 9; greatest length of skull 14.1, 13.9; zygomatic breadth 7, 8.3; interorbital breadth 3.8, 3.7; length of maxillary toothrow 5, 5.3.

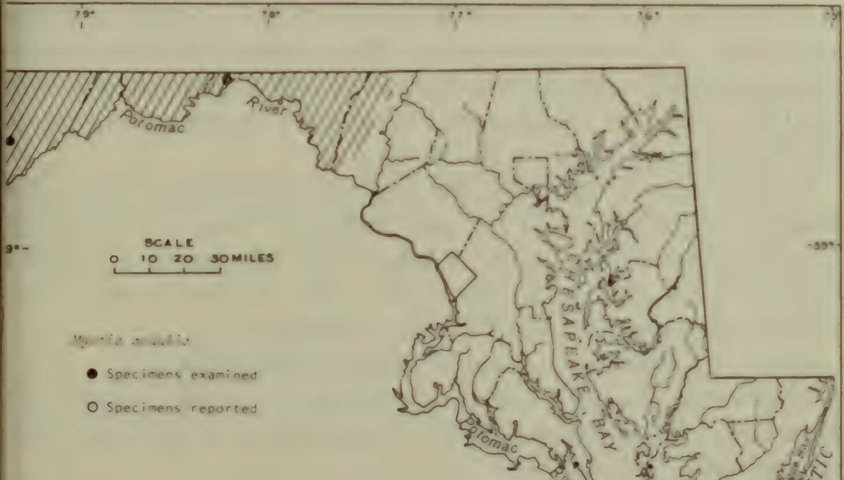

FIGURE 16.—Distribution of *Myotis sodalis*.

The skull of an adult from Oakland, Garrett County, measures: Greatest length 13.7; zygomatic breadth 8.1; interorbital breadth 3.7; length of maxillary toothrow 5.0.

Habitat and habits.—This bat roosts almost exclusively in limestone caves, preferring those in which there are considerable bodies of water. It forms large colonies and is often found in association with *M. lucifugus.* It is known from only 2 localities in Maryland.

Hall (1962) has thoroughly studied the life history of this bat. He found that at Blackball Mine, La Salle County, Ill., the earliest date for entrance into hibernation was 14 September. The major buildup of the hibernating colony was during October and the first part of November. The hibernating colony starts diminishing in early April, and by the first week of June no *sodalis* are in hibernation. He estimates that the average hibernation period for this species would be from 15 October to 20 April, or 187 days. He found that large numbers of Indiana myotis accumulate in a few caves to hibernate, and that for five consecutive winters the species was found in the same seven caves and in no others in Edmondson County, Kentucky. This species also occupies caves during the nonhibernating summer months, and may be considered a true cave species.

As far as movements and migrations are concerned, Hall says that the same individual may be present in one area winter and summer whereas others may move as much as 250 miles between seasons. He says that the few band recoveries indicate that certain movement areas exist for certain populations. For instance, he found that one such population range includes Kentucky, Indiana, Illinois, and southern Ohio, and that no movement takes place between this area and the Ozark area of Arkansas and Missouri.

Little is known regarding the feeding and breeding habits of *M. sodalis*, but probably they are quite similar to those of *M. lucifugus.* Like that species, *M. sodalis* is long-lived. One specimen banded in Carter County, Ky., on 12 March 1950, was recovered in good health 14 years later on 8 January 1964, in the same cave.

Specimens examined.—Garrett County: Near Oakland, 1.

Other records and reports.—Washington County: Round Top Mountain, near Hancock (bat banding record, U.S. Fish and Wildlife Service).

Remarks.—The skull of the Maryland specimen is small in all measures, but otherwise appears to be typical *M. sodalis.* It has the slight but perfectly defined sagittal crest which is generally present in this species and lacking in *M. lucifugus.* Unfortunately, the skin is missing from the National Museum collections.

SMALL-FOOTED MYOTIS

Myotis subulatus leibii (Audubon and Bachman)

espertilio leibii Audubon and Bachman, Jour. Acad. Nat. Sci. Philadelphia, ser. 1, 8 : 284, 1842.

yotis winnemana Nelson, Proc. Biol. Soc. Wash., XXVI : 183, 8 August 1913. (Type from Plummers Island, Maryland.)

Type locality.—Erie County, Ohio.

General distribution.—Ontario and southwestern Quebec, south to western orth Carolina, and west to southern Iowa, eastern Kansas, and northeastern klahoma.

Distribution in Maryland.—Recorded from Plummers Island, ontgomery County, and Round Top Mountain near Hancock, Wash-gton County. This species probably hibernates in caves in the Alle-heny Mountain section, and passes through the rest of the State uring migrations.

Distinguishing characteristics.—Similar to *Myotis lucifugus*, but iffers in its smaller size, golden tinted fur, black ears, black facial ask, and shorter forearm. The skull is much flatter than that of *M. ucifugus*, and the braincase narrower.

Measurements.—Two adults from Plummers Island, Montgomery ounty (the first the type of *M. winnemana* Nelson) measure as fol-ws: Total length 82, 80; tail vertebrae 39, 35; hind foot 8, 7; greatest

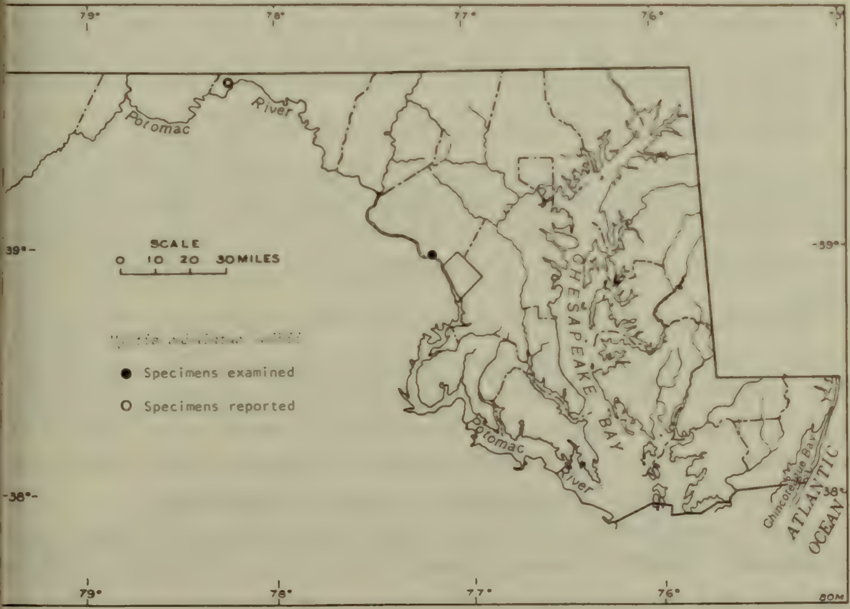

FIGURE 17.—Distribution of *Myotis subulatus leibii*.

length of skull 13.7, 13.1; interorbital breadth 3.4, 3.3; length of maxillary toothrow 5.1, 5.0.

Habitat and habits.—These bats probably hibernate in caves in the wild forested regions of the Allegheny Mountains and migrate elsewhere in the State during late winter and early spring. Most specimens have been taken in caves located in hemlock forests. The position of these bats as they hang on the walls or ceilings of the caves is a definite means of identification. The arms, instead of hanging parallel to the body, as generally found in *M. lucifugus* and other bats, are extended about 30 degrees from the vertical. Little is known of the feeding and breeding habits, but they are presumed to be similar to *M. lucifugus.*

Specimens examined.—Montgomery County: Plummers Island, 2.

Other records and reports.—Washington County: Round Top Mountain, near Hancock (bat banding record, U.S. Fish and Wildlife Service).

SILVER-HAIRED BAT

Lasionycteris noctivagans (Le Conte)

V[*espertilio*]. *noctivagans* Le Conte, in McMurtrie, The animal kingdom . . . by the Baron Cuvier, vol. 1, App., p. 431, 1831.

Type locality.—Eastern United States.

General distribution.—Nearly all of North America, from the tree line in northern Canada, south to Georgia, Texas, New Mexico, and California.

Distribution in Maryland.—Probably breeds only in the Allegheny Mountain section, but occurs in all sections of the State as a migrant in the spring and the fall.

Distinguishing characteristics.—Teeth 2/3, 1/1, 2/3, 3/3, = 36; pelage dark brownish-black, the ends of the hairs tipped with silver, giving a somewhat frosted effect, particularly along the middle of the back; fur extends onto dorsal surface of interfemoral membrane; ears short and rounded with broad, blunt tragus; skull flattened, and rostrum broad.

Measurements.—An adult male from Plummers Island, Montgomery County has the following external measurements: Total length 116; tail vertebrae 47; hind foot 10. Some cranial measurements of four adults from Washington, D.C. are: Greatest length 15.8 (15.6–16.2); zygomatic breadth (2 specimens) 9.9, 9.1; interorbital breadth 4.1 (4.0–4.3); length of maxillary toothrow 5.7 (5.6–5.8).

Habitat and habits.—This bat is found most frequently flying about ponds and streams in wooded areas. It roosts in hollow trees, in dense foliage, and occasionally in buildings. It is sociable and often encountered in large groups. As in many species of bats, there is a marked

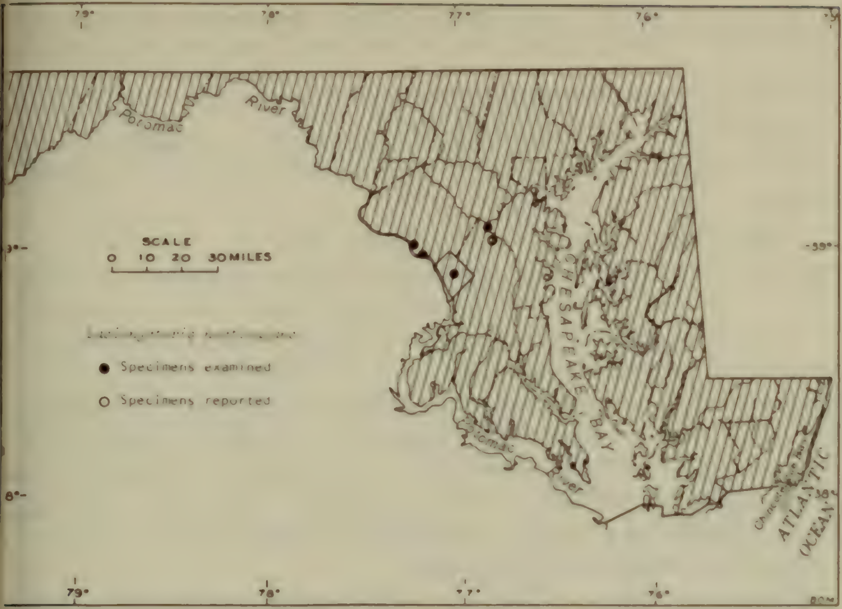

FIGURE 18.—Distribution of *Lasionycteris noctivagans.*

egregation of the sexes and the large colonies seem to be composed rimarily of females. Solitary animals are usually males.

The breeding habits of this species are not well known, but accordng to Jackson (1961, p. 86) it usually has two young, born blind and early naked, the last part of June or early in July. The young remain linging to the breast of the mother until they are about 3 weeks old, vhen they are able to fly and shift for themselves. A single litter is roduced each year.

The silver-haired bat feeds entirely on nocturnal insects, particularly hose that fly high in the woodlands or over the borders of watercourses vith wooded banks.

Specimens examined.—Montgomery County: Great Falls, 1; Plumners Island, 1. *Prince Georges County:* Laurel, 1. *District of Columia:* 5.

Other records and reports.—Prince Georges County: Patuxent Reearch Center (Gardner, 1950*b*, p. 112).

EASTERN PIPISTRELLE

Pipistrellus subflavus subflavus (F. Cuvier)

V[*espertilio*]. *subflavus* F. Cuvier, Nouv. Ann. Mus. Hist. Nat. Paris, 1: 17, 1832.

Type locality.—Georgia, restricted to the LeConte Plantation, 3 miles SW Riceboro, Liberty County, by Davis (1959, p. 522).

General distribution.—From central Minnesota and southern Quebec south into Georgia and western Florida; west to Oklahoma, Texas, and Tamaulipas. The center of its abundance is the Ohio River Valley; north of this it occurs locally in summer (Davis and Mumford, 1962, p. 396).

Distribution in Maryland.—Probably ranges throughout all sections of the State, although there are no records of it from the Eastern Shore section.

Distinguishing characteristics.—Teeth 2/3, 1/1, 2/2, 3/3, = 34; smallest bat in Maryland; coloration of dorsum grayish to reddish-brown, each hair tricolored, plumbeous at base, dark brown at tip, with central portion yellowish-brown; flight weak and erratic, giving the animal somewhat the appearance of a large fluttering moth.

Measurements.—External measurements of 11 adults from Washington, D.C., are as follows: Total length 81.6 (75–90); tail 39.5 (37–42); hind foot 8.5 (8.0–9.0). Some cranial measurements of 10 adults from Washington are as follows: Greatest length 12.8 (12.4–13.1); zygomatic breadth 7.9 (7.7–8.2); interorbital breadth 3.5 (3.4–3.6); length of maxillary toothrow 4.3 (4.2–4.4).

Habitat and habits.—This is a wide-ranging species that hibernates in caves, mine shafts, and rock crevices. During the summer months it probably spends the daylight hours in trees, although it is sometimes found in buildings. It is most frequently encountered in wooded areas near water. The pipistrelle is believed to have a feeding range of at least 5 or 6 miles, and a homing instinct has been demonstrated by tracing banded bats for distances up to 80 miles. Individuals roost year after year in the same cave.

Mating occurs in November, and young are born the last part of June or early July. Usually two constitute a litter, but there are occasionally triplets, and sometimes only a single offspring. By the time they are about a month old they are able to fly, and shortly thereafter begin to shift for themselves. Since pipistrelles are so small their food is probably restricted to insects such as flies, moths, and the smaller bugs and beetles.

Despite their diminutive size, pipistrelles apparently have a long life span. Banded individuals have been recovered in good health as long as 10 years after they were originally tagged.

Specimens examined.—*Anne Arundel County:* Magatha R. (= Magothy River?), 2. *Charles County:* Marshall Hall, 13. *Garrett County:* Near Oakland, 1. *Montgomery County:* Capitol View, 1; Glen Echo, 1; Great Falls, 1; Plummers Island, 2. *Prince Georges County:* Hyattsville, 1; Laurel, 1; near D. C. line, 6. *St. Marys County:* St. George Island, 4; *District of Columbia:* 40.

Other records and reports.—*Baltimore County:* Bare Hills (Bures, 1948: 64); Orange Grove (Hampe, 1939: 5). *Washington County:*

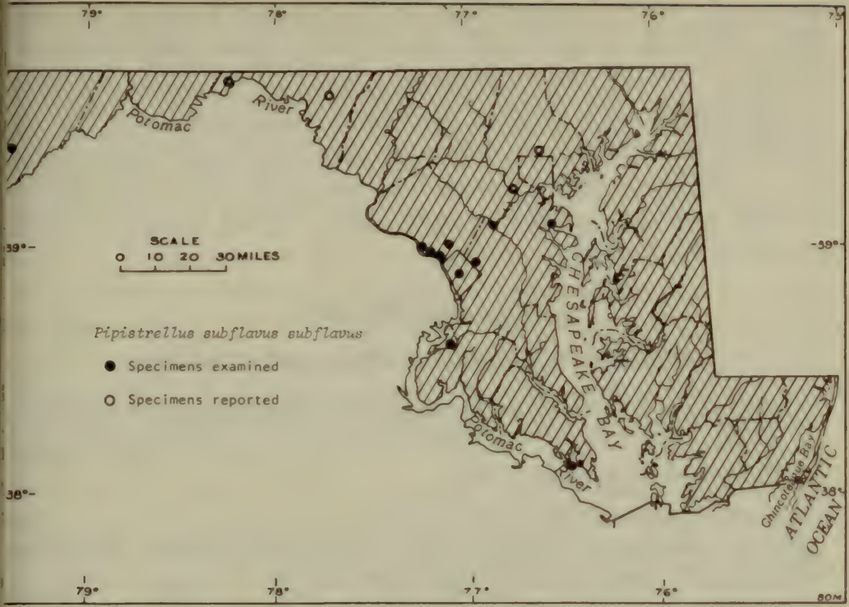

FIGURE 19.—Distribution of *Pipistrellus subflavus subflavus.*

Keedysville, Snively's Cave No. 1 (bat banding record, U.S. Fish and Wildlife Service); Round Top Mountain (bat banding record, U.S. Fish and Wildlife Service).

Remarks.—Two subspecies of *Pipistrellus subflavus* have been named from the eastern United States, *P. s. subflavus*, the typical form as described above, and *P. s. obscurus* Miller (Type locality: Lake George, Warren County, New York). Miller (1897, p. 93) described *obscurus* as differing from *subflavus* only in coloration, being somewhat darker, duller, and more yellowish. Several specimens from the vicinity of Washington, D.C., in the national collections, are darker than typical *P. s. subflavus* and were referred by Bailey (1923, p. 136) and Gardner (1950b, p. 112) to *obscurus*. Bailey (1923, p. 137) says that "They may have migrated from their northern habitat, or merely wandered out of their regular range after the breeding season was over." As pointed out by W. H. Davis (1959, p. 523), who has synonomyzed *P. s. obscurus* with *P. s. subflavus*, there is a wide range of individual variation in color in this species, and dark specimens are found throughout the entire range of *P. s. subflavus*. The dark specimens from the vicinity of Washington, referred to *obscurus* by both Bailey and Gardner, fall within the range of individual variation of color in the subspecies *subflavus*.

Another Maryland specimen which exhibits atypical coloration is from St. George Island, St. Marys County. It is similar to *P. s. florid-*

anus Davis, which is distributed over peninsular Florida and southeastern Georgia. W. H. Davis (1957, p. 215) speculated that perhaps this animal actually was a *floridanus* that had wandered northward. In a later publication (1959, p. 524), however, he says that unless it can be shown that this actually happened it is best to refer this specimen to *P. s. subflavus*. The specimen has been in the National collections for many years (collected 20 August 1887), and the unusual coloration is perhaps due to fading.

BIG BROWN BAT

Eptesicus fuscus fuscus (Palisot de Beauvois)

Vespertilio fuscus Palisot de Beauvois, Catalogue Raisonné du Muséum de Mr. C. W. Peale, Philadelphia, p. 18 (p. 14 of English ed. by Peale and Beauvois), 1796.

Type locality.—Philadelphia, Pa.

General distribution.—Eastern North America, from Quebec, Ontario, and Manitoba, south into Florida and Nuevo León, México.

Distribution in Maryland.—Abundant in the lower Piedmont and upper Western Shore sections in the vicinity of the fall line. Uncommon in the Allegheny Mountain, Ridge and Valley, and Eastern Shore sections.

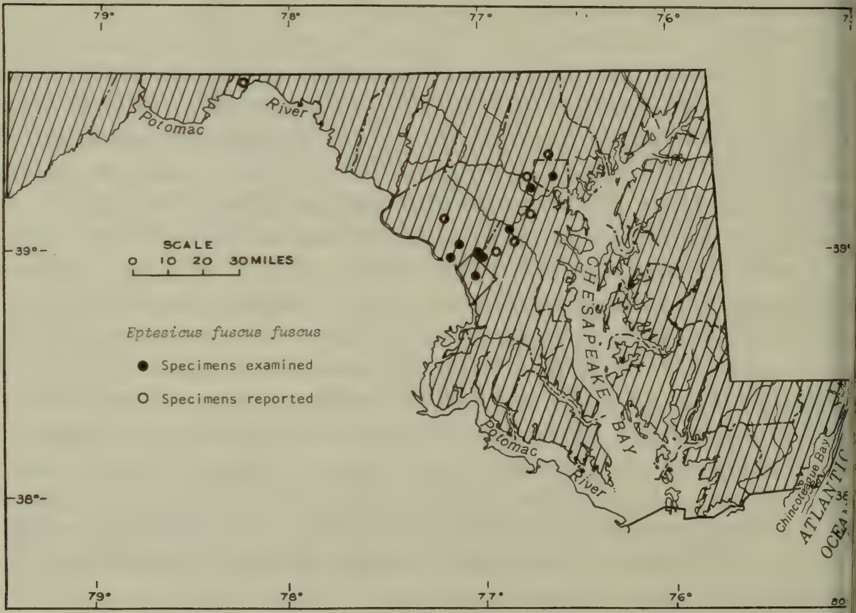

FIGURE 20.—Distribution of *Eptesicus fuscus fuscus*.

Distinguishing characteristics.—Teeth 2/3, 1/1, 1/2, 3/3, = 32; size arge, exceeded in Maryland only by the hoary bat; coloration uniormly dark brown; ears thick and heavy, somewhat rounded and nedium in size, naked except for some fur at the base; wings and interemoral membrane lacking fur; skull larger and heavier than any other ocal bat except *Lasiurus cinereus*, from which it differs in being noticebly narrower. Both *Eptesicus* and *Lasiurus* have 32 teeth, but in *Eptesicus* there are 2 upper incisors and 1 upper premolar, while in *Lasiurus* there are 2 upper premolars and 1 upper incisor on each side.

Measurements.—External and cranial measurements of 15 adults from Washington, D.C., are as follows: Total length 113.2 (110–122); ail 43.6 (40–48); hind foot (average of 9) 12 (10–13); greatest length of skull 18.5 (17.5–19.6); zygomatic breadth (average of 10) 12.6 (12.1–13.4); interorbital breadth 4.2 (3.9–4.5); length of maxillary toothrow 7.1 (6.9–7.4).

Habitat and habits.—This bat usually occurs around buildings and dwellings where it roosts in the daytime under windowsills, in the eaves of roofs, in cracks or crevices, or behind doors, blinds, and awnings. It is sometimes found in hollow trees, under loose bark, and occasionally in caves or crevices in cliffs. This species is common in parts of Maryland; it is an unusual year when at least one specimen is not captured in the Natural History building of the National Museum and added to the study collection. The big brown bat does not form large colonies as do some species of bats. Probably it is in part migratory, but does not engage in extensive seasonal migrations, other than to find a suitable place for hibernation. This is one of the last bats to hibernate in the fall, and it is on wing again in early March. During mild spells of winter it may be seen flying in the sun at midday (Hamilton, 1943, p. 90). These bats are long-lived; records of banded animals recovered 10 to 15 years later are numerous.

The homing instinct seems to be developed to some degree. Cohen (1944) found several adults behind the shutter of a house in Berwyn, Prince Georges County, and after banding them released them on 4 October 1941, in Baltimore City. Twelve days later, on 15 October 1941, one of these bats was found hanging on the same shutter from which it had been removed in Berwyn. It had travelled a distance of 26.56 miles, over the congested city of Baltimore, and heavily travelled highways, to return to its home roost.

The mating season for the big brown bat is September, and young are born the following June. Normally two comprise a litter, although there may occasionally be only one. The young grow rapidly and 3 or 4 weeks after birth are able to shift for themselves.

This species, like all Maryland bats, is primarily insectivorous. Hamilton (1933a) examined 2,200 summer fecal pellets from northern

West Virginia and concluded that the most common insects consumed by the big brown bat in summer are (in order of abundance of remains): Coleoptera, Hymenoptera, Diptera, Plecotera, Ephemirida, Hemiptera, Tricoptera, Neuroptera, Mecotera and Northoptera. No lepidopterous remains were discovered by Hamilton in the pellets.

Specimens examined.—Baltimore City: 1. *Baltimore County:* Catonsville, 1. *Montgomery County:* Kensington, 1; Plummers Island, 2; Silver Spring, 1; Takoma Park, 2. *Prince Georges County:* Laurel, 3. *District of Columbia:* 86.

Other records and reports.—Anne Arundel County: Jessup (Silver 1928, p. 149). *Baltimore County:* Bare Hills (Cohen, 1942, p. 96); Patapsco State Park (Hampe, 1939, p. 5). *Montgomery County.* Washington Grove (Christian, 1956, p. 66). *Prince Georges County.* Berwyn (Cohen, 1944, p. 65); Patuxent Research Center (Gardner 1950*b*, p. 112). *Washington County:* Round Top Mountain, near Hancock (banding record).

RED BAT

Lasiurus borealis borealis (Müller)

Vespertilio borealis Müller, Des Ritters Carl von Linne . . . vollständiges Natursystem nach der zwolften lateinischen Ausgabe. . . Suppl. (Mammalia), p. 20, 1776.

Type locality.—New York

General distribution.—Eastern North America, from southern New Brunswick Quebec, Ontario, Manitoba, Saskatchewan, and Alberta, south to Florida an Texas.

Distribution in Maryland.—Abundant in all sections of the Stat

Distinguishing characteristics.—Teeth 1/3, 1/1, 2/2, 3/3, = 32; siz medium; color bright rufous or fulvous, hairs plumbeous at base an whitish at tips, producing a slight frosted effect; ears broad and blun rounded at tip, reaching about halfway from the angle of the mout to the nostril when laid forward; tail moderately long; interfemor membrane thickly furred on upper surface.

This bat is easily distinguished from all other bats in Maryland b its bright rufous coloration and the furred interfemoral membran Males generally are darker and more reddish than females.

Measurements.—An adult male from Doubs, Frederick County, an an adult female from 3 miles NW of Annapolis, Anne Arund County, measure respectively: Total length 109, 113; tail 49, 50; hir foot 10, 7; greatest length of skull 13.0, 12.6; zygomatic breadth 9. 9.5; interorbital breadth 4.4, 4.2; length of maxillary toothrow 4.5, 4.

Habitat and habits.—This bat shows a preference for deciduo woodlands, orchards, and city parks with trees and tall shrubs. generally chooses the branch of a shady tree in which to roost, som

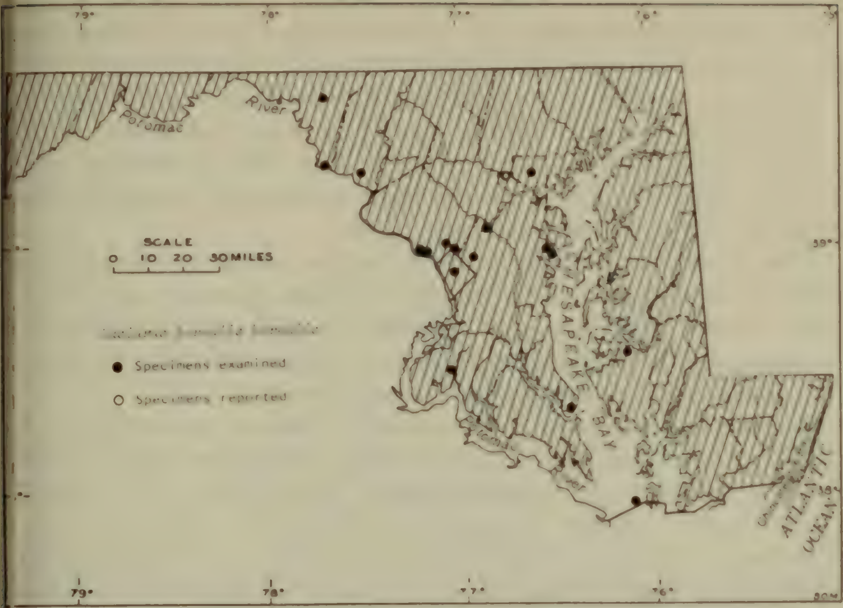

FIGURE 21.—Distribution of *Lasiurus borealis borealis.*

mes within a few feet of the ground, and conceals itself in the foliage.

It is well known that the red bat is migratory in habits, spending mmers in northern areas and flying south in the autumn. They are ot found in the winter in the more northern areas, while their num- ers appear to increase in the south. In Maryland they apparently ccur the year round, specimens having been taken in all months rom April through December, and in nearby Arlington, Va., on March. Whether the same population occurs here in the summer in the winter is not known. Perhaps the summer population migrates rther south and its place is taken by a more northern population hich has migrated in.

It appears that this bat migrates southward in the fall behind an dvancing cold front. David Bridge, a Maryland bird bander, tells e that he often takes red bats in the autumn in his bird nets at Kent oint on Kent Island, Queen Annes County, for several days following e movement of a cold front through the area.

The red bat is a strong swift flyer. Jackson (1961, p. 96) states that bservational timing he made of it would indicate an ordinary raightaway flying speed of near 40 miles per hour. It has sometimes een observed flying far out to sea as much as 500 miles from the earest land. Usually it migrates at night, but occasionally it is ob- rved during the day. A. H. Howell (1908, p. 36) observed over a hundred bats, most of which were probably of this species, passing over a part of Washington, D.C., between 9 and 10 a.m. on the cloudy mild morning of 28 September 1907.

Red bats mate during early August; copulation occurs while the bats are in flight. The female apparently stores the sperm, and the young are not born until the following June after a gestation period of 80 to 90 days. Three are the usual number of young per litter, although there are occasionally two or four.

Like other Maryland bats, the red bat is insectivorous and catches most of its prey while on wing. Some insects, however, are probably taken from the foliage or even near the ground, since remains of crickets have been found in stomachs. Additional items of diet are flies, bugs, beetles, cicadas, and other insects.

Specimens examined.—Anne Arundel County: Annapolis, 1; Annapolis, 3 miles NW, 1; no exact locality, 2. *Baltimore City:* 1. *Calvert County:* Solomons, 1. *Charles County:* Port Tobacco, 1½ miles SW, 2. *Dorchester County:* Cambridge, 1. *Frederick County:* Doubs, 1. *Montgomery County:* Forest Glen, 6; Glen Echo, 1; Plummers Island, 7; Silver Spring, 2. *Prince Georges County:* College Park, 1; Laurel, 14. *Somerset County:* off Tangier Island, Virginia, 1; *Washington County:* Hagerstown, 2; Sandy Hook, 1. *District of Columbia:* 83.

Other records and reports.—Baltimore County: Patapsco State Park (Hampe, 1939, p. 5). *Queen Annes County: Kent Point* (bird bander, David Bridge in verbis, 16 September 1964).

Remarks.—A closely related species, the seminole bat, *Lasiurus seminolus* (Rhoads), which normally is found in Florida, southern Georgia, Alabama, Mississippi, and Louisiana, has been reported twice from southeastern Pennsylvania (Poole, 1932, p. 162; 1949, p. 80), and once from central New York (Layne, 1955, p. 453). Layne suggests that individuals of this species may wander northward far out of the normal range in summer, and if this is so, the seminole bat may eventually be taken in Maryland. This species is distinguished from the red bat by its much darker coloration, a rich mahogany brown slightly frosted with white.

HOARY BAT

Lasiurus cinereus cinereus (Palisot de Beauvois)

Vespertilio cinereus (misspelled *linereus*) Palisot de Beauvois, Catalogue raisonné du muséum de Mr. C. W. Peale, Philadelphia, p. 18, 1796.

Type locality.—Philadelphia, Pa.

General distribution.—Most of North America, from the Atlantic to the Pacific, north into Canada, and south into Mexico. Breeds in the northern part o its range, mostly north of the United States.

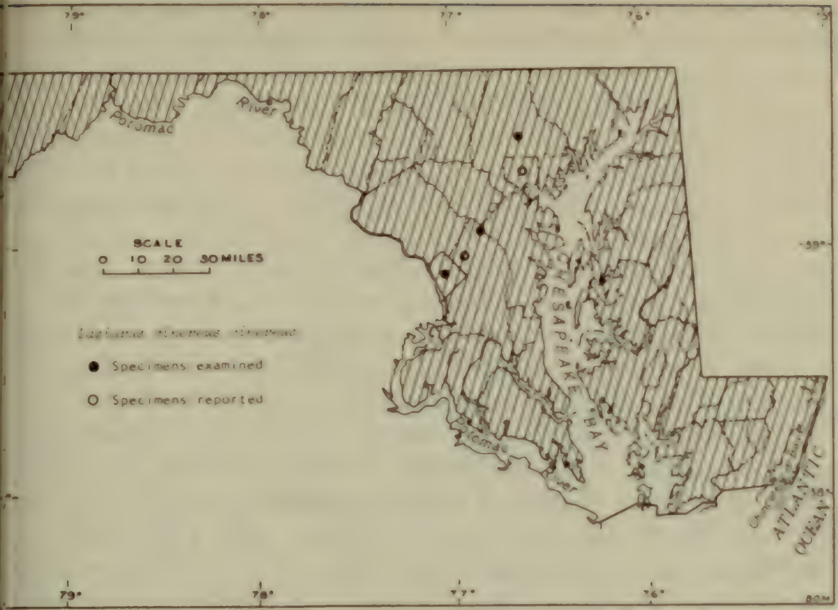

FIGURE 22.—Distribution of *Lasiurus cinereus cinereus.*

Distribution in Maryland.—Occurs as a migrant in all sections of the tate; may breed in the higher portions of the Allegheny Mountain ection.

Distinguishing characteristics.—Teeth as in *L. borealis;* size large averaging 135 mm in total length) ; wingspread averaging around 14 nches; coloration a mixture of grayish umber and chocolate brown, eavily tinged with white, so as to produce a hoary effect, especially on he back; head blunt, with ears large and rounded, conspicuously immed with black or dark brown; tail medium length, about 40 perent of total length of the animal; interfemoral membrane thickly urred on upper surface nearly to the edge; anterior edge of underide of wing furred for about half its length. This bat is easily disnguished from all other Maryland bats by its large size and unique oloration.

Measurements.—Measurements of an adult male from Washington, .C., are as follows: Total length 135.5; tail 61.5; hind foot 13; greatt length of skull 16.1; zygomatic breadth 12.0; interorbital breadth .9; length of maxillary toothrow 6.2.

An adult female from Washington, D.C., has the following cranial easurements: Greatest length of skull 16.9; zygomatic breadth 12.7; nterorbital breadth 5.5; length of maxillary toothrow 6.2.

Habitat and habits.—This is a migratory species. It breeds and pends the summer in the northern part of its range, from southeastern Pennsylvania and possibly the higher mountains of the Appalachians, north into Canada. It migrates southward quite late in the season. It prefers to roost in coniferous forests, but may also be found in farmyards, city parks, and yards, particularly where coniferous trees are growing. The hoary bat has an extensive home range and may fly a mile or more from its roosting site in search of food. It is a strong and rapid flyer, and Jackson (1961, p. 100) estimates that it can achieve speeds of up to 60 miles an hour. The scarcity of records and specimens from Maryland indicates that it is rare here. In the summer, it occurs in the higher mountains of the Allegheny Mountain section. In other seasons, it may be encountered throughout Maryland.

Little is known of the breeding habits of this bat. Jackson (1961, pp. 100–101) says that mating probably occurs in September or October and the young are born in May or June, thus giving an apparent gestation period of about 8 months. It seems probable, however, that as in some other species of bats spermatozoa survive in the uterus through the winter, and that fertilization takes place early in the spring, giving an actual gestation period of about 90 days. Usually, two young comprise a litter, although it is possible that as many as four may be produced.

The hoary bat is primarily an insect feeder, but occasionally preys on smaller bats.

Specimens examined.—Baltimore County: Cockeysville, 1. *Prince Georges County:* Laurel, 1. *District of Columbia:* 3.

Other records and reports.—Baltimore City (Merriam, 1887, p. 86). *Prince Georges County:* Berwyn (Tromba, 1954, p. 253).

EVENING BAT

Nycticeius humeralis humeralis (Rafinesque)

Vespertilio humeralis Rafinesque, American Monthly Mag., 3 (6) : 445, October 1818.

Type locality.—Kentucky.

General distribution.—From Pennsylvania, Michigan, and Illinois, south int Florida and Texas, and west into eastern Oklahoma and Kansas.

Distribution in Maryland.—Probably absent in the higher mountains of the Allegheny Mountain and Ridge and Valley sections, bu elsewhere it may occur sparingly as a summer resident.

Distinguishing characteristics.—Teeth 1/3, 1/1, 1/2, 3/3, = 30; superficially resembles *Myotis* but can be easily distinguished by th reduced number of teeth and the short sparse brown fur which is dul umber above and plumbeous at the base; fur on abdomen paler tha on dorsum; ears small and thick. The young of this species are considerably darker than the adults.

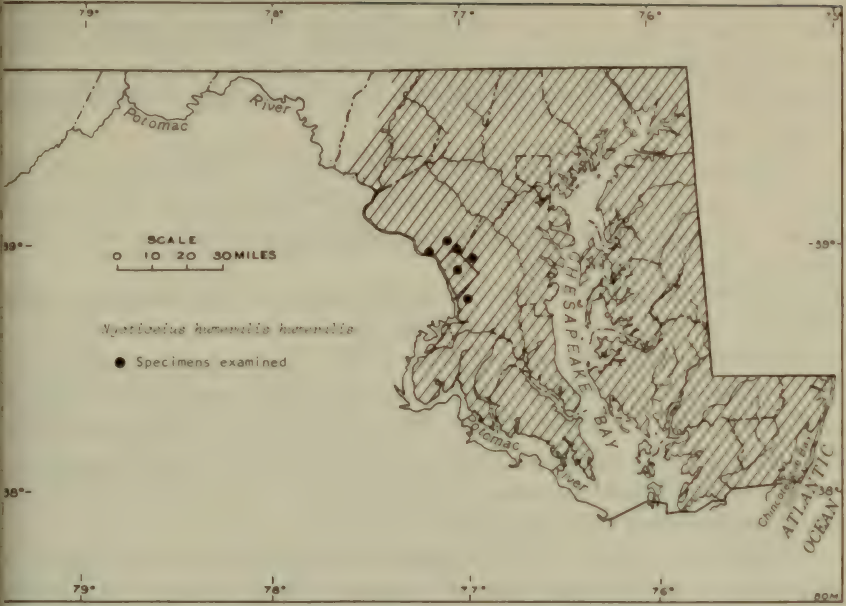

FIGURE 23.—Distribution of *Nycticeius humeralis humeralis.*

Measurements.—Three adults from the vicinity of Washington, .C., have external measurements as follows: Total length 90, 95, 94; il 39, 35, 35; hind foot 10, 9, 8. Six adults from the vicinity of Washgton have the following cranial measurements: Greatest length 14.2 13.7–15.5); zygomatic breath 9.7 (9.6–10.0); interorbital breadth 3.9 3.8–4.0); maxillary toothrow 5.2 (5.0–5.4).

Habitat and habits.—This is essentially a southern species that waners north in summer sometimes as far as Pennsylvania, Michigan, and llinois. It prefers to roost in hollow trees, flying out with a slow and eady flight as darkness falls. It gives birth to two young, generally late May. Little else is known of its habits or life history.

Specimens examined.—*Montgomery County:* Linden, 1; Plummers sland, 1; Silver Spring, 1. *Prince Georges County:* Hyattsville, 2; xon Hill, 1; near D.C. line, 1. *District of Columbia:* 6.

(BIG-EARED BAT)

Plecotus townsendii virginianus (Handley)

orynorhynus virginianus Handley, Jour. Washington Acad. Sci., 45 (2): 148, 23 May 1955.

Type locality.—Schoolhouse Cave, 4.4 miles NE of Riverton, 2,205 feet, Pendlen County, W. Va.

General distribution.—Central part of the Appalachian highlands in eastern entucky, western Virginia, and eastern West Virginia.

Distribution in Maryland.—Not as yet recorded, but should be looked for in the higher portions of the Allegheny Mountain section. To date it has not been found resident in any Maryland caves, but it probably enters the State on feeding forays from caves in nearby West Virginia and Virginia.

Distinguishing characteristics.—Teeth 2/3, 1/1, 2/3, 3/3, = 36, ears very long; glandular masses on nose appear as lumps; fur long and limp; colored a dark brown above, and pinkish buff on belly, interfemoral membrane naked.

The very large ears serve to distinguish this bat from any others that may be encountered within Maryland.

Measurements.—Handley (1959, p. 233) gives some measurements of a series of adults from West Virginia as follows: Total length 101 (98–103); tail vertebrae 50 (48–52); hind foot 11 (10–12); ear from notch 34 (31–38); greatest length of skull 16.5 (16.2–16.8); zygomatic breadth 8.8 (8.6–9.0); interorbital breadth 3.7 (3.6–3.9); length of maxillary toothrow 5.3 (5.2–5.4).

Habitat and habits.—This is a true cave bat usually roosting in small groups and emerging at dusk to fly at considerable heights. After dusk it descends nearer the ground, sometimes at an elevation of only several feet, searching for insect prey. When roosting in the caves during the day, the long ears are spirally coiled and flattened against the neck. It is a shy bat, quick to take alarm. With its large ears, it can detect the least sound and seems to be more wary than other species.

Although Pearson et al. (1952) have made a detailed study of the life history of the western subspecies of *Plecotus townsendii*, little is known concerning the habits of the eastern race. Since the two are widely separated geographically, much of Pearson's findings may not be applicable to the eastern form. Hamilton (1943, pp. 102–103) says that the eastern race bears its young during late June and that the mother carries the single offspring until it becomes too heavy. As with other vespertilionid bats, the spermatozoa are probably stored over winter in the uteri of the females and are capable of fertilizing in the spring.

This species is insectivorous, and Hamilton (1943, p. 104) says that those examined for a clue to their feeding habits contained only the remains of Lepidoptera in their stomachs.

Remarks.—This bat has never been taken within Maryland, but has been found in several caves very close to the border of the western part of the State, in Grant, Preston, and Tucker Counties, W. Va.

During the Pleistocene, a bat very similar to this species did inhabit Maryland caves. Gidley and Gazin (1933, p. 345) described *Corynorhynus alleganiensis* (=*Plecotus alleganiensis*) from Pleistocene deposits in Cumberland Cave, Allegany County, Md. Handley (1959, p.

10) states that *P. alleganiensis* was similar in many respects to (and possibly directly ancestral to) *P. townsendii.*

Order LAGOMORPHA (rabbits, hares, etc.)

Family LEPORIDAE (rabbits, hares)

EASTERN COTTONTAIL

Sylvilagus floridanus mallurus (Thomas)

L[*epus*]. *n*[*uttalli*]. *mallurus* Thomas, Ann. Mag. Nat. Hist., ser. 7, 2:320, October 1898.

Type locality.—Raleigh, N.C.

General distribution.—Primarily east of the Appalachian Mountains, from Massachusetts, south into central Florida, west to Tennessee and Alabama.

Distribution in Maryland.—Occurs abundantly in all sections of the State. Cottontails have been introduced into parts of Maryland from areas outside the range of *mallurus*, and hence all population in the State may not be referrable to that race.

Distinguishing characteristics.—Teeth 2/1, 0/0, 3/2, 3/3, = 28; size small; ears large, pelage long and coarse, reddish brown, mixed with black on the dorsum; underparts white, including the underside of the tail; nape and legs cinnamon-rufous. This species differs from the New England cottontail (*S. transitionalis*), which has not yet been taken in Maryland but which probably occurs in the mountains of the western part of the State, in several external and cranial characters which are described under that species.

Measurements.—External measurements of three adults from the three adults from Washington, D.C., are: Basilar length 57.5, 57.0, 458; tail 60, 64, 75; hind foot 99, 84, ——. Cranial measurements of three adults from Washington D.C., are: Basilar length 57.5, 57.0, 56.5; zygomatic breadth 36.9, 36.5, 36.3; interorbital breadth 19.1, 18.5, 17.9; length of maxillary toothrow 14.1, 14.0, 13.2.

Habitat and habits.—This rabbit occupies a variety of habitats from the marshes of the Delmarva Peninsula to the fields and meadows of western Maryland. It is seldom encountered in heavy woods. It occurs on Assateague Island, off the Atlantic coast of Maryland, where it is particularly abundant in the wooded thickets and dry sandy areas adjacent to the marshes. These rabbits are found in the tall grass and thickets in villages and towns and even in the large cities such as Baltimore and Washington. The summer food consists of almost any type of green vegetation, but it seems to be especially fond of legumes, dandelions, plantains, and lettuce. During winter it eats tender parts of many shrubs and trees and will gnaw away the bark of some species of

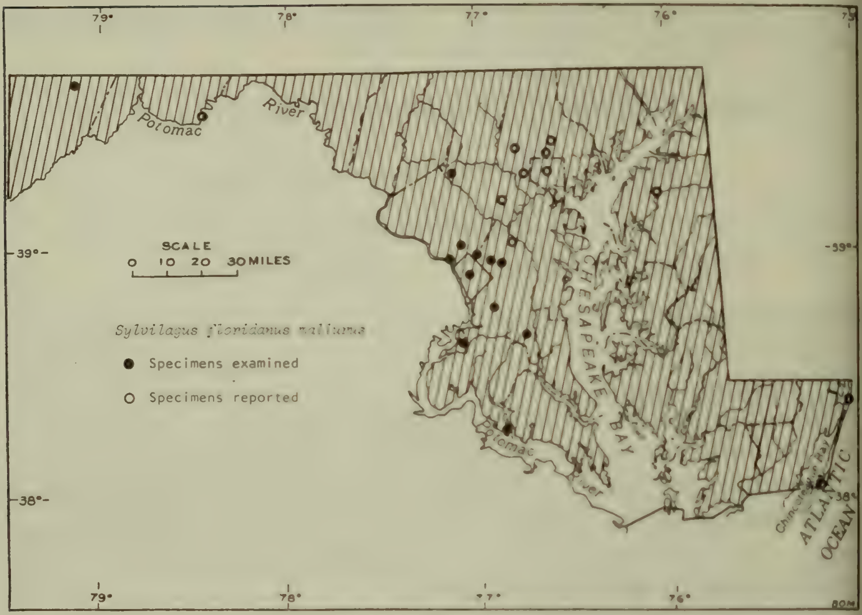

FIGURE 24.—Distribution of *Sylvilagus floridanus mallurus.*

trees. With the deforestation of much of Maryland since Colonial times the cottontail has found more suitable habitat and today is abundant throughout the State.

The cottontail is both diurnal and nocturnal, but is most active during the first 3 or 4 hours after daylight and from 2 to 3 hours before sunset to about 1 hour after sunset. It does not hibernate, but is active yearlong. Cottontails are solitary and seldom are two or more found together except in the case of mother and young.

The female builds a brood nest of grass combined with fur plucked from her own abdomen. The nest, placed in a depression in the ground, is about 4 or 5 inches in diameter and depth. It is usually well concealed in grass, weeds, thickets, or scrubby woods. In addition to the brood nest, the cottontail makes forms that are used as hiding or resting places. These forms are made by scratching or trampling a shallow oval hollow in the ground and sometimes lining it with grass, leaves, or fur.

Cottontails in Maryland mate in late winter. The gestation period varies from 28 to 32 days, and the first litter of the year appears by mid-March. Two or three litters are produced each season, and the number of young per litter varies from three to six, with five being the most frequent.

Specimens examined.—Charles County: Marshall Hall, 1; Rock Point, 1. *Garrett County:* Grantsville, 1. *Howard County:* Long Corner, 2. *Montgomery County:* Kensington, 1; Plummers Island, 2; Takoma Park, 1; no exact locality, 1. *Prince Georges County:* Clinton, 1; East Riverdale, 1; Lanham, 1; Westwood, 1; no exact locality, 3. *District of Columbia:* 24 (many of these are labeled "purchased in Washington Market" and were probably taken outside the District of Columbia area).

Other records and reports.—Allegany County: Oldtown, 9 miles E (personal observation). *Baltimore City:* (personal observation). *Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948, p. 68); Loch Raven (Kolb, 1938); Gwynnbrook State Game Farm (Sheffer, 1957, p. 90); Patapsco State Park (Hampe, 1939, p. 7). *Howard County:* Atholton (personal observation). *Kent County:* Chestertown (U.S. Fish and Wildlife Service files). *Prince Georges County:* Patuxent Research Center (Herman and Warbach, 1956, p. 85). *Worcester County:* Assateague Island, near the Virginia border (personal observation); Ocean City, 1 mile N (personal observation).

Remarks.—Nelson (1909, p. 168) considers the specimen from Grantsville in the extreme western Allegheny Mountain section to be a distinct intergrade with *S. f. mearnsi*, nearly pale enough to be classified with *mearnsi.*

(NEW ENGLAND COTTONTAIL)

Sylvilagus transitionalis (Bangs)

Lepus sylvaticus transitionalis Bangs, Proc. Boston Soc. Nat. Hist., XXVI, pp. 405–407, 31 January 1895.

Type locality.—Liberty Hill, New London County, Conn.

General distribution—Distributed from southeastern Maine, southern New Hampshire, and Vermont, south through eastern New York, New Jersey, and eastern Pennsylvania and along the Allegheny Mountains through West Virginia to northern Georgia and northeastern Alabama.

Distribution in Maryland.—There are no valid records of the New England cottontail from Maryland, but it almost certainly occurs in the Allegheny Mountain section at higher elevations.

Distinguishing characteristics.—Similar in coloration to the eastern cottontail, except that the underfur is a much darker gray. The back is ochraceous buff, overlaid with a wash of black-tipped guard hairs which give it a dark appearance. The ears are short and round and have a black margin on the outside edge, making a distinct black line which does not blend gradually into the browner color of the ear as in the eastern cottontail. A definite black patch is between and just in front of the ears.

Cranially this species differs from the eastern cottontail in that the skull is lighter and slenderer, the interorbital breadth narrower, and the rostrum thinner. The supraorbital process is very slender, narrowing anteriorly so that the notch is absent, or virtually so. The posterior portion of the process is very narrow and in some instances is free of the skull, leaving a distinct foramen. The auditory bullae are noticeably smaller in this species than in *S. floridanus.*

Measurements.—Nelson (1909, p. 168) gives average measurements of five adults from Wilmington, Mass., as follows: Total length 388; tail vertebrae 39; hind foot 96; basilar length of skull 54.8; interorbital breadth 17.1.

Since geographic variation appears to be slight in this species, Maryland specimens, if taken, probably would not differ greatly in size from the Massachusetts series.

Habitat and habits.—Llewellyn and Handley (1945, p. 384) say that in Virginia

> All specimens examined were taken at elevations above 3,000 feet in the Allegheny Mountains. Signs indicate that these cottontails occupy the woods and brush along most of the higher crests and ridges of the state.

They believe that the species will be found in Virginia only at elevations above 3,000 feet. Since the species occurs in the Alleghenies to the north and south of Maryland, and since there are several mountains in western Maryland that exceed 3,000 feet in altitude, it is almost certain that the New England cottontail is resident in Maryland and will eventually be taken there.

This species is similar to *Sylvilagus floridanus* with regard to breeding habits and food preferences.

Remarks.—The records of Nelson (1909, p. 199) for the occurrence of the New England cottontail in Washington, D.C., and in nearby Alexandria, Va., have been shown by Bailey (1923, pp. 120–121) to be erroneous. He says:

> They have been recorded from the District . . . and from Alexandria, but the record based on 2 young taken in a nest in the Soldiers Home grounds by Dr. C. W. Richmond on 20 June 1886 was erroneously included under this species, and a specimen which I bought on 1 January 1904 of a colored man on the street who said he killed it at Alexandria, probably came from West Virginia where they are common and are often included in shipments of rabbits to market.

SNOWSHOE RABBIT

Lepus americanus virginianus Harlan

Lepus virginianus Harlan, Fauna Americana, p. 196, 1825.

Type locality.—Blue Mountains, near Harrisburg, Pa.

General distribution.—Southern Ontario, and northeastern United States, from southern Maine, south in the Appalachian Mountains to North Carolina and Tennessee.

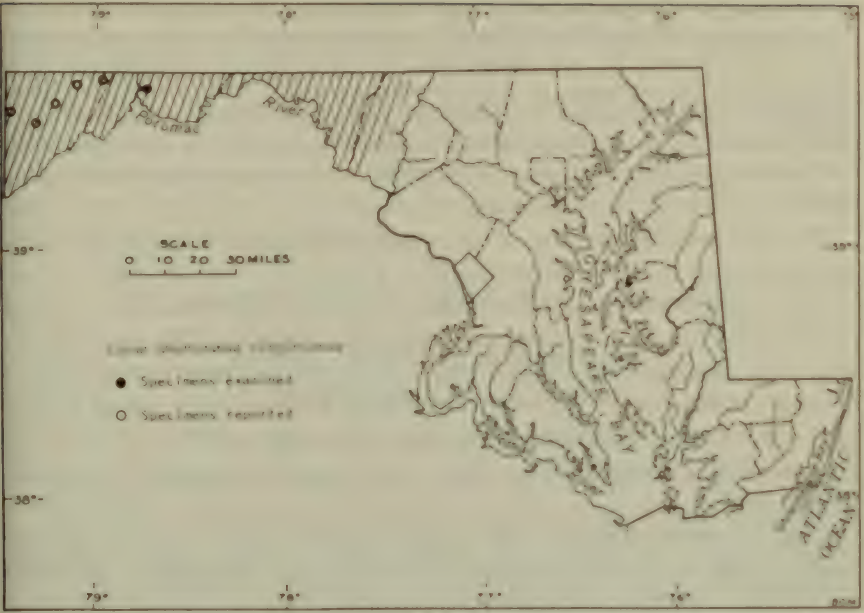

FIGURE 25.—Distribution of *Lepus americanus virginianus.*

Distribution in Maryland.—Occurs in the Allegheny Mountain and Ridge and Valley sections where it is now uncommon.

Distinguishing characteristics.—A medium-sized rabbit with large hind feet and thick fur. Coloration in summer pelage, dull rusty brown varying to buffy brown, always more or less darkened by a wash of black. In winter, coloration is sometimes pure white with a little dusky around tips of ears; but frequently a dull brownish wash is present on the feet and terminal half of the ears.

Cranially, this species differs from *Sylvilagus floridanus* and *S. transitionalis* in its larger size and heavier build, with much stronger development of the supraorbitals which are subtriangular and stand out broadly winglike with a broad open notch between the posterior process and the skull.

Measurements.—Nelson (1909, p. 86) gives average measurements of five adults from Pennsylvania as follows: Total length 518; tail vertebrae 49; hind foot 414; basilar length of skull 65.0; interorbital breadth 22.0.

Habitat and habits.—This rabbit prefers areas of spruce in the highest regions of the Allegheny Mountain and Ridge and Valley sections, where it has been observed in open woods and thickets. Spruce areas are small and scattered districts in the upland swamps and on some of the mountain tops.

Mansueti (1953, pp. 72–73) says that

> The varying hare seems to be destined to permanent extirpation in Maryland. It is a species with specialized habitat requirements and one of limited distribution. Its environment is being encroached upon by civilization gradually in some and swiftly in other places. . . . The optimum habitat is forest of the high intermountain Allegheny Plateau which has at least a moderate understory of small trees and shrubs to provide food and cover. These areas are gradually being destroyed by an increasing deer herd as well as human expansion in Garrett County.

The last reliable reports of snowshoe rabbits in Maryland were by John Hamlet, formerly with the U.S. Fish and Wildlife Service, who reported that in 1945 he observed a female in Garret County but did not record the exact locality, and by John Smith of Mountain Lake who shot one near the Holy Cross Camp, Deep Creek Lake, Garrett County, in March 1957. This latter animal was probably one of 18 that had been shipped into the country from the Adirondacks of New York and released in March 1952. (Maryland Conservationist 34 (2), p. 25, March 1957.)

The snowshoe rabbit is active in the summer and winter, primarily early in the morning and late in the evening. Although it constructs no nests, it returns to the same spot regularly so that a form is eventually hollowed out. This form is nearly always concealed under grass, brush, shrubbery, or a fallen log.

This species breeds promiscuously. Mating begins early in March and may continue well into April. The first litter appears in April after a gestation period of about 36 days; as many as four litters a year are possible during a breeding season, although there are usually only two. The number of young may range from one to five or more, but most frequently three or four.

Food of the snowshoe rabbit in summer consists of dandelion, grasses, clover, ferns, and the tender parts of certain shrubs and trees. In winter, when many summer foods are not available, it feeds on bark and shoots of woody plants.

Specimens examined.—Allegany County: Cumberland, 1.

Other records and reports.—Garrett County: Cranesville Swamp area (Mansueti, 1953, p. 72); Deep Creek Lake (Maryland Conservationist 34(2), p. 25, March 1957); Finzel (Mansueti, 1953, p. 72, says that a specimen from this locality is in the collections of the U.S. National Museum and lists it among his specimens examined. There is no record, however, that a specimen from Finzel has ever been in the National Museum collections. Rhodes (1903, pp. 119–120) quotes Merriam as saying that Preble was told of the occurrence of *Lepus virginianus* at Finzel, Md., only half a mile from the Pennsylvania line. Mansueti may have confused this record with the specimen of *Lepus a. virginianus* from Cumberland, Md., which is in the National Museum collections, and which is probably the one he examined.);

Little Crossings, headwaters of North Branch of Castleman River (Browning, 1928, p. 242); Wolf Swamp, SE of Grantsville (Mansueti, 1953, p. 72).

Remarks.—Several hundred snowshoe rabbits have been stocked at various times in several localities in western Maryland. None of these introductions appear to have been very successful, although the specimen taken by John Smith at Deep Creek Lake in March 1957 seems to be one of those stocked in 1952.

Order RODENTIA (gnawing mammals)

Family SCIURIDAE (squirrels)

EASTERN CHIPMUNK

Tamias striatus (Linnaeus)

[*Sciurus*] *striatus* Linnaeus, Syst. nat., ed. 10, 1: 64, 1758.

The eastern chipmunk is distributed from Quebec, New Brunswick, and Nova Scotia, south into Georgia and Louisiana, west to eastern Oklahoma, Kansas, Nebraska, North and South Dakota, and Saskatchewan. In Maryland, two subspecies are recognizable. They are—

Tamias striatus fisheri A. H. Howell

Tamias striatus fisheri A. H. Howell, J. Mammal., 6(1): 51, 9 February 1925.

Type locality.—Merritts Corners, 4 miles E of Ossining (Sing Sing), Westchester County, N.Y.

This type locality has been the source of some confusion in the literature. It has been listed by various authorities as "Merritt's Corners, four miles W of Sing Sing [= Ossining] New York," (Howell, 1925, p. 51); "Merritts Corners, 4 miles E of Ossining (Sing Sing), N.Y.," (Howell, 1929, p. 16); "Merritts Corners, 4 miles W of Sing Sing (Ossining), Westchester County, N.Y.," (Poole and Schantz, 1942, p. 560); "Merritts Corners, 4 miles E of Ossining (Sing Sing), Westchester County, N.Y." (Miller and Kellogg, 1955, p. 218): "Merritts Corners, 4 miles W Ossining (Sing Sing), Westchester County, N.Y.," (Hall and Kelson, 1959, p. 294).

The confusion involves whether Merritts Corners, a small New York State village not found on current maps of the region, actually lies west or east of Ossining, N.Y., and hence west of the Hudson River in Rockland County or east of the Hudson in Westchester County.

The locality as listed on the original label of the type specimen (U.S.N.M. Cat. No. 193370, collected on 23 August 1884, by A. K. Fisher) reads: "Sing Sing, N.Y." and on the back is written "Merritts Corners 4 miles E of Sing Sing." U.S. Geological Survey maps of the region (1893 edition, reprinted 1897) reveal that Merritts Corners, the type locality of *T. s. fisheri*, is located east of the Hudson River, in Westchester County, N.Y., at 41°11′27″ N lat., and 73°47′51″ W long., and is approximately 3¾ miles E and 1¾ miles N of Ossining, N.Y.

General distribution.—Middle Atlantic States, from the lower Hudson River Valley in New York, south to Virginia and West Virginia.

Distribution in Maryland.—Uncommon in the Eastern Shore and Western Shore sections; abundant locally in the Piedmont and Ridge and Valley sections. In the Allegheny Mountain section it is replaced by the subspecies *T. s. lysteri.* (see fig. 26.)

Distinguishing characteristics.—Teeth 1/1, 0/0, 1/1, 3/3, = 20; a small, heavyset ground squirrel with dense, moderately fine fur; pelage marked by two pale and three dark stripes on sides of face and five blackish and four pale stripes extending down the back; rump rusty in coloration; top of head and dark facial stripes near russet, light facial stripes pale buffy; dark stripes on back nearly black in color, paler stripes near smoke-gray shading posteriorly into russet; center or inner pale stripe is the broadest and always gray in coloration; tail moderately long, grayish red and not bushy. This species may be distinguished from any other in Maryland by the striping pattern of the pelage.

Measurements.—Four adults from the District of Columbia have the following external measurements: Total length 243.2 (234–255); tail 90.2 (83–99); hind foot 34.1 (33–35). Cranial measurements of nine adults from the vicinity of Washington, D.C., are as follows: Greatest length 39.5 (38.9–40.3); zygomatic breadth 22.0 (21.3–22.8); postorbital breadth 11.2 (10.6–12.2); length of nasals 13.2 (12.5–14.0).

Habitat and habits.—The chipmunk is largely a ground dweller, only rarely climbing trees. It prefers to live on wooded hillsides or mountain slopes, but is also fond of stone walls and rail fences. Though usually favoring dry situations, it is occasionally found in moist bottom land woods. It spends a good deal of time in burrows which it digs beneath a rock, stone wall, tree roots, or a building. The burrow is sometimes as much as 20 feet in length and 1 to 3 feet below the surface of the ground. The chipmunk in Maryland remains more or less active during the winter. All summer long, and especially in the autumn, it is busily engaged in storing food, primarily seeds and nuts for winter use. This food is kept in a "storeroom" adjoining the rooms where the animal is spending the winter. The food of the chipmunk consists of small seeds, berries, fruits, and nuts, and occasionally small birds, mice, snakes, snails, slug, insects, and other small animal life. Chipmunks are polyestrous and breed from March onward. The number of young is three to five, and the gestation period 31 days. Puberty is reached at the age of 2½ to 3 months.

Specimens examined.—*Anne Arundel County:* Epping Forest (near Annapolis), 2. *Frederick County:* Catoctin State Park, 1. *Harford County:* Fallston, 3. *Howard County:* Long Corner, 2. *Montgomery County:* Bethesda, 1; Chevy Chase, 2; Dickerson, 1; Rockville, 3; Takoma, 1; Washington Grove, 2; Linden, 1. *Prince Georges County:* Laurel, 5. *District of Columbia:* 42.

Other records and reports.—Baltimore County: Bare Hills–Lake Roland Area (Bures, 1948, p. 67); Lock Raven (Kolb, 1938); Patapsco State Park (Hampe, 1939, p. 6). *Montgomery County:* Sligo; Piney Branch; Silver Spring; Sandy Spring (all from Bailey, 1896, p. 95); Plummers Island (Goldman and Jackson, 1939, p. 133). *Prince Georges County:* Patuxent Research Center (Herman and Warbach, 1956, p. 87). *Worcester County:* near Milburn Landing (Vagn Flyger, personal communication, 22 June 1964).

Tamias striatus lysteri **(Richardson)**

Sciurus (*Tamias*) *lysteri* Richardson, Fauna Boreali-Americana, 1: 181, pl. 15, June 1829.

Type locality.—Penetanguishene, Ontario.

General distribution.—Nova Scotia, New Brunswick, and southeastern Ontario, south into Connecticut and Pennsylvania and in the Appalachian Mountains to western Maryland.

Distribution in Maryland.—Occurs in the higher mountains (above 2,000 feet altitude) of the Allegheny Mountain section where it is abundant.

Distinguishing characteristics.—This subspecies is similar to *T. s. fisheri*, but has paler upper parts, especially the rump and the median grayish bands. This paler coloration is most marked in the northern

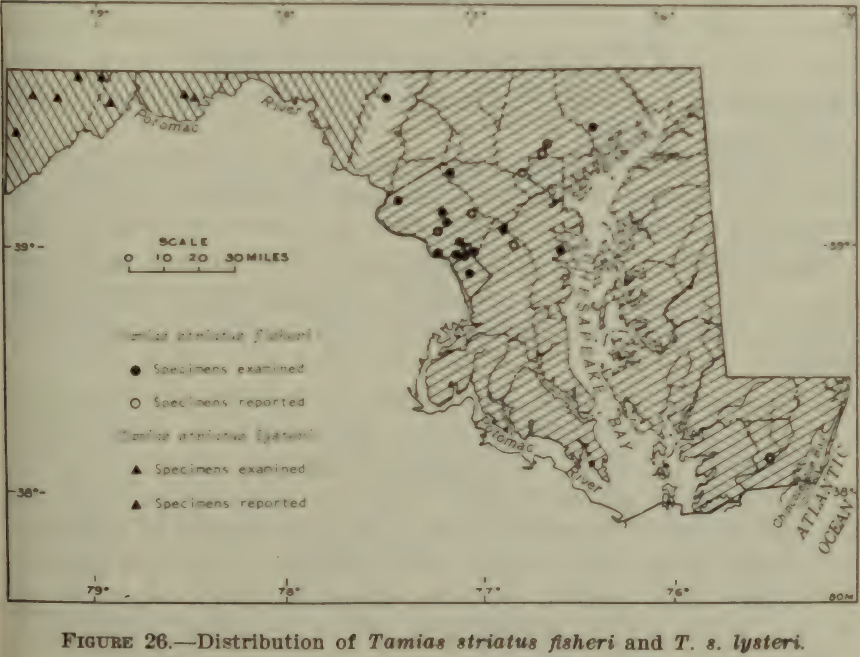

FIGURE 26.—Distribution of *Tamias striatus fisheri* and *T. s. lysteri*.

part of the range of the subspecies in the vicinity of the type locality. Maryland specimens are not so pale as typical *lysteri*.

Cranially the differences between the two subspecies are very slight. *T. s. lysteri* averages somewhat smaller, and has relatively longer nasal bones.

Measurements.—External measurements of five adults and cranial measurements of four adults from Garrett and Allegany Counties, Md., are as follows: Total length 233.4 (220–247); tail 87.8 (81–100); zygomatic breadth 21.2 (19.9–22.2); postorbital breadth 10.9 (10.5–11.2); length of nasals 13.5 (12.7–14.0).

Habitat and habits.—Similar to *T. s. fisheri.*

Specimens examined.—Allegany County: Dans Mountain (4 miles northwest of Rawlings), 1. *Garrett County:* Bittinger, 1; Cunningham Swamp, 1 (Coll. U. Md.); Finzel, 4; Grantsville, 1; Herrington Manor, 1.

Other records and reports.—Allegany County: Accident (Howell, 1929, p. 19).

Remarks.—All Maryland specimens assigned to this subspecies represent intergrades between *T. s. lysteri* and *T. s. fisheri* in coloration, size, and relative length of nasals, and assigning them to *lysteri* is somewhat arbitrary. Specimens from Fallston, Harford County, are also intergrades but are closer to *fisheri* and have been assigned herein to that subspecies.

WOODCHUCK

***Marmota monax monax* (Linnaeus)**

[*Mus*] *monax* Linnaeus, Syst. nat., ed. 10, 1: 60, 1758.

Type locality.—Maryland.

General distribution.—Middle eastern United States from Pennsylvania, New Jersey, Ohio, Indiana, Illinois, Lower Peninsula of Michigan, and Iowa, south to Arkansas and the northern parts of Alabama, Georgia, and South Carolina.

Distribution in Maryland.—Abundant in all sections except the Eastern Shore, where it has until lately been unknown. There is recent evidence, however, that the species is extending its range into that section.

Distinguishing characteristics.—Teeth 1/1, 0/0, 2/1, 3/3, = 22; the heaviest member of the squirrel family found within the State (weight 5 to 12 lbs.); tail short and somewhat bushy; fur thick and coarse; coloration above grizzled brown, with top of head, face, legs, and tail dark brown to blackish brown; under parts lighter in coloration, and pelage not so thick; incisor teeth white; ears short and rounded.

The large size, grizzled brownish coloration, and short bushy tail readily distinguish this animal from any other rodent in Maryland.

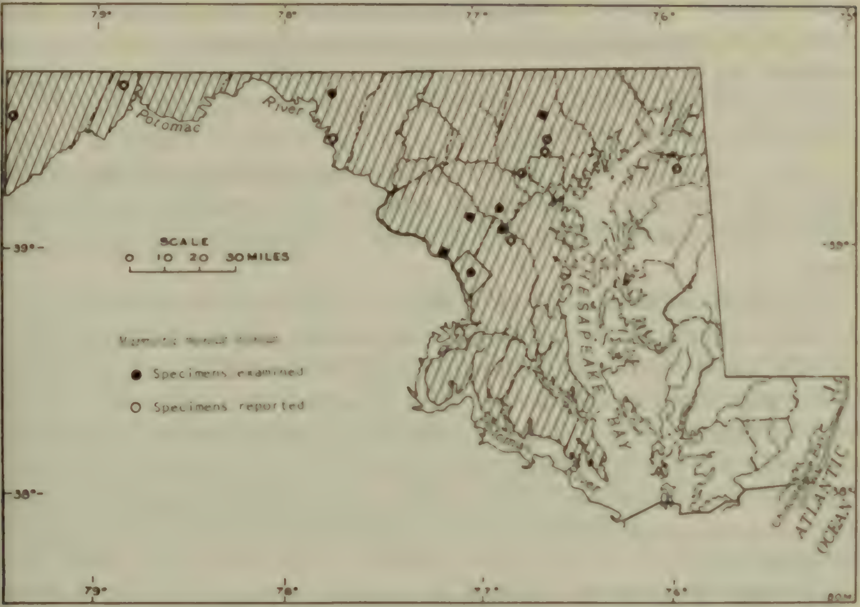

FIGURE 27.—Distribution of *Marmota monax monax*.

Measurements.—Males average larger than females in overall size. Two adult females, one from Sparks, Baltimore County, and the other from Washington, D.C., have external measurements as follows: Total length 628, 615; tail 157, 148; hind foot 88, 86. Cranial measurements of three adult males from the District of Columbia and nearby Maryland are as follows: Condylobasal length 102.6, 97.5, 95.7; palatal length 59.3, 56.2, 55.3; zygomatic breadth 69.3, 65.8, 65.9; least interorbital breadth 27.3, 25.9, 27.2; maxillary toothrow 21.7, 21.6, 22.0. Cranial measurements of five adult females average: Condylobabal length 91.3 (89.0–94.2); palatal length 53.5 (51.0–56.0); zygomatic breadth 62.5 (59.6–64.8); least interorbital breadth 24.6 (23.3–26.3); maxillary toothrow 21.1 (20.4–21.8).

Habitat and habits.—This is primarily a forest border and open field mammal, seldom found in heavy dense woods. It prefers the edges of brushy woodlands, and particularly open fields along streams. Woodchucks are found along poorly cleared fence lines, in meadows, cow pastures, and grainfields, especially where rocky outcroppings or old stumps occur. They are common on the bluffs that line the Maryland side of the Potomac River, and occur in great numbers in the farming country of Montgomery and Frederick Counties. Hampe (1939, p. 6) reports that they are very abundant throughout the Patapsco State Park, and that numerous burrows are found in the hillsides along the river. In the Bare Hills–Lake Roland region of Baltimore County, Bures (1948, p. 67) found that they were not very common, their range being limited to areas of cultivation and the region between the deciduous woods and the marsh. Woodchucks abound in Garrett County, particularly in the vicinity of Deep Creek Lake.

This species is active both day and night and is frequently seen in grassy shoulders and rocky outcroppings that border Maryland highways. On many occasions it falls victim to modern high-speed traffic and is one of the most frequently encountered road-kills in the State.

The woodchuck inhabits an extensive burrow which sometimes extends to a depth of 5 feet and may be some 30 feet in length. The burrow usually has several entrances, which may be located beneath a wall or tree stump. Within the burrow, there is usually one chamber in which a bulky grass nest is situated. In this chamber the female gives birth to four or five young in April or May after a gestation period of about 4 weeks. The babies remain in the den for about a month, after which their eyes open, and they become completely independent of the mother by early July.

Principal food of the woodchuck consists of grasses and succulents such as clover, alfalfa, plaintain, and various perennials, in addition to beans, peas, corn, and apples; seldom does the woodchuck consume flesh, although it has been known to pursue poultry and eat insects and snails. During the summer it becomes fat on these foods, and early in the autumn when the first frost is on the ground it descends into its burrow and goes into hibernation. It usually emerges again in late February or early March.

Specimens examined.—Baltimore County: Sparks, 1. *Howard County:* Simpsonville, 1. *Montgomery County:* Plummmers Island, 4; Sandy Spring, 1. *Prince Georges County:* Laurel, 5; near Washington, D.C., 1. *Washington County:* Hagerstown, 1. *District of Columbia:* 6.

Other records and reports.—Allegany County: Mount Savage (Coll. U. Md.). *Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948, p. 67); Lock Raven (Kolb, 1938); Patapsco State Park (Hampe, 1939, p. 6). *Garrett County:* Cranesville Pine Swamp (Mansueti, 1958, p. 83). *Kent County:* Galena (Allen, 1950, p. 28). *Prince Georges County:* Patuxent Research Center (Grizzell, 1949, p. 74). *Washington County:* Sharpsburg, 1 mile W (personal observation).

Remarks.—Allen (1950, p. 28) says that the Eastern Shore is one of those regions that has been invaded by the woodchuck in the last 50 years. It first appeared on the Prettyman Farm near Galena in Kent County around 1900. Evidently it is spreading southward around the Chesapeake Bay from Pennsylvania.

GRAY SQUIRREL

Sciurus carolinensis pennsylvanicus Ord

Sciurus pennsylvanica Ord, in [Guthrie], a new geographical, historical and commercial grammar; . . . , Philadelphia, ed. 2, 2: 292, 1815.

Type locality.—Pennsylvania, west of the Allegheny Ridge.

General distribution.—From southern New Brunswick, Quebec, and Ontario, south into Virginia and in the Appalachians to Tennessee, west into eastern Iowa and southern Minnesota.

Distribution in Maryland.—Abundant in all sections of the State.

Distinguishing characteristics.—Teeth 1/1, 0/0, 2/1, 3/3, = 22; size large; tail bushy and flattened; coloration variable both in summer and winter; upper parts usually yellowish brown in summer, with a slightly grayish cast to the sides of the neck, the shoulders, and thighs; face clay colored to cinnamon buff; forelegs gray above, hind legs reddish; tail brown at base, hairs blackish near middle and tipped with gray; in winter pelage, paler and more grayish.

A melanistic color phase occurs frequently in this species, particularly in *S. c. pennsylvanicus*. Albinistic animals are also often encountered.

Measurements.—External and cranial measurements of three adult males from Cambridge, Dorchester County, are as follows: Total length 462, 486, 465; tail vertebrae 201, 216, 190; hind foot 64, 64, 61;

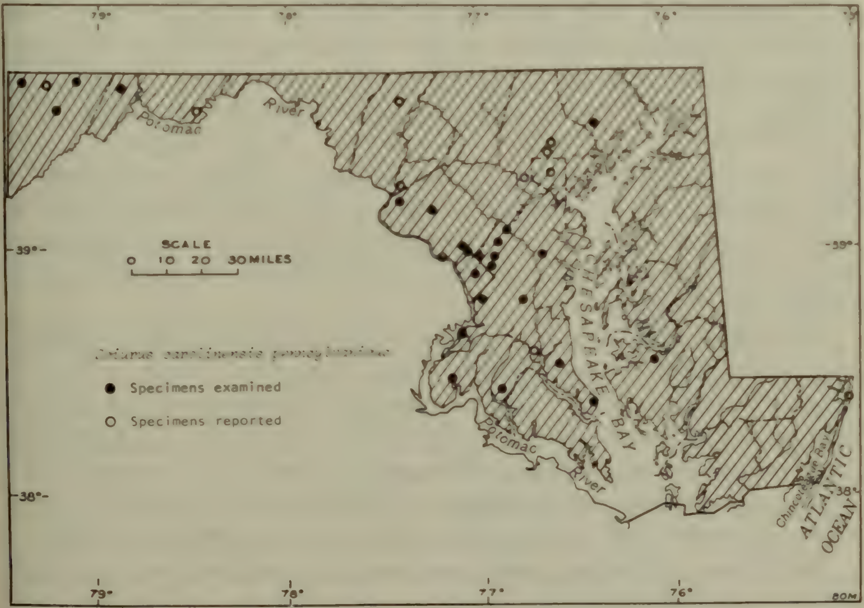

FIGURE 28.—Distribution of *Sciurus carolinensis pennsylvanicus*.

greatest length of skull 62.6, 62.4, 62.8; zygomatic breadth 33.4, 33.4, 33.6; least interorbital breadth 16.9, 19.2, 18.2; length of maxillary toothrow 10.9, 11.6, 11.2.

Habitat and habits.—This is a squirrel of the hardwood and mixed coniferous-hardwood forests, particularly those with nut-bearing trees and bushy undergrowth. It is quite common in the parks of Washington, D.C., particularly Rock Creek Park. Most of these are descended from introduced stock. Bailey (1923, p. 108) says:

> The late Dr. William L. Ralph purchased many gray squirrels and liberated them in the Smithsonian grounds, where up to the time of his death in 1907 he fed and cared for them . . . They soon became common in the Mall . . . and spread to the White House grounds, LaFayette Square, and other city parks.

Melanistics squirrels were introduced and liberated into the National Zoological Park and are still frequently seen there. Of these, Bailey (1923, p. 109) says:

> The first shipment of 10 (black squirrels) was from Rondeau Provincial Park, Morpeth, Ontario, 18 May 1906; and these squirrels were immediately liberated in the northwestern part of the zoo where they were very much at home. They have since been constanly in the park, especially from the vicinity of the great flight cage to the Klingle Valley and they have spread northward to Cleveland Park and nearly to Chevy Chase.

Five of the 31 skins of gray squirrels in the National Museum collections from the District of Columbia show melanistic tendencies.

The gray squirrel is common throughout Maryland. Hampe (1939, p. 6) says that it is the most common squirrel in the Patapsco State Park and has been observed in the Park every month of the year; young squirrels are numerous there after the first of July. Bures (1948, p. 67) says the gray squirrel is quite common in the Bare Hills-Lake Roland area. I found them numerous on the Delmarva Peninsula; in southern Maryland; in the Piedmont region, particularly in the vicinity of Sugar Loaf Mountain; and in the mountains of the western part of the State. Gray squirrels do not occur on Assateague Island, but I have seen them in the thickets back of the dunes several miles north of Ocean City.

The gray squirrel is most at home in trees and descends to the ground only when necessary to obtain food and bury nuts. It does not hibernate, even in the coldest northern portions of its range. This squirrel is diurnal and is most active in the early morning and late afternoon.

Its bulky nest is generally constructed in an enlarged natural cavity of an old oak tree, but sometimes an outdoor nest of firmly woven leaves is constructed among the branches or in the crotch of a tree.

Squirrels mate during midwinter, and the gestation period is about 40 days. A second mating usually occurs sometime in May or June. The young are two to five (generally four) in number. When 2 months of age, they are weaned, but remain with the mother until she has her second litter.

The gray squirrel is generally vegetarian in habits, its food consisting of many kinds of nuts (including acorns), seeds, fruits, buds, fungi, inner bark of certain trees, and occasionally corn and other grains, and fleshy parts of plants. Sometimes it eats small amounts of animal food such as insects or an occasional bird's egg or small bird.

Specimens examined.—Allegany County: Mount Savage, 1 (Coll. U. Md.). *Anne Arundel County:* Priest Bridge, 1. *Calvert County:* Little Cove Point Area, 2; Prince Frederick, 1. *Charles County:* Marshall Hall, 1; Newport, 1; Port Tobacco, 2. *Dorchester County:* Cambridge, 3. *Garrett County:* Friendsville, 1/4 mile NW, 1 (Coll. U. Md.); Grantsville, 2; Meadow Mountain, 1 (Coll. U. Md.). *Harford County:* Fallston, 5. *Montgomery County:* Dickerson, 1; Germantown, 2; Kensington, 1; Takoma Park, 2; Woodside, 1. *Prince Georges County:* Beltsville, 1; Bladensburg, 2; Branchville, 1; College Park, 1; Fort Washington, 1; Laurel, 22; (Upper) Marlboro, 2; Muirkirk, 1; Oxon Hill, 1; Patuxent River (fork), 2; Piscataway Creek, 2; Scagg's Swamp, 1. *District of Columbia:* 40.

Other records and reports.—Allegany County: South end of Town Hill Mountain (personal observation). *Baltimore City* (Flyger, 1960b, p. 366). *Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948, p. 67); Loch Raven (Kolb, 1938); Patapsco State Park (Hampe, 1939, p. 6). *Frederick County:* Thurmont (Coll. U. Md.); Sugar Loaf Mountain (personal observation). *Garrett County:* Keyser's Ridge (Coll. U. Md.); *Montgomery County:* Plummers Island (Goldman and Jackson, 1939, p. 133). *Prince Georges County:* Aquasco (Herman, and Reilly, 1955, p. 402). *Worcester County:* Ocean City, 2 miles N (personal observation).

Remarks.—All of Maryland was formerly included within the range of the southern subspecies of gray squirrel, *Sciurus carolinensis carolinensis* Gmelin (see Bangs, 1896, p. 153, and Miller, 1924, p. 223). Patton (1939, pp. 75–76), however, in a study of the distribution of the gray squirrel in Virginia, concluded that *S. c. carolinensis* occupies the southern half of the Piedmont Plateau and the entire Coastal Plain region in that State. He says that in Virginia the area of intergradation between *S. c. carolinensis* and *S. c. leucotis* (= *pennsylvanicus*) lies along a line drawn from central King George County to southeastern Patrick County, and he assigned a specimen from Eastville, on the Virginia portion of the Delmarva Peninsula, to *S. c. carolinensis.* This suggests that, although most of Maryland lies within the range of *S. c. pennsylvanicus*, the southern portions of the Western Shore and Eastern Shore sections are within the range of *S. c. carolinensis*, and the range of the species in Maryland has been mapped in this way by

Hall and Kelson (1959, p. 371). However, a careful comparison of specimens from Calvert and Charles Counties in the Western Shore Section and Cambridge in the Eastern Shore section with specimens of typical *pennsylvanicus* from central Pennsylvania and New York show that they differ in no essential respect from that subspecies, whereas they are considerably larger and paler than typical *carolinensis*. I have also examined the specimen from Eastville, Va., assigned by Patton (1939) to *carolinensis*, and consider it to be referable to *pennsylvanicus*. It is somewhat darker than typical *pennsylvanicus*, but can be matched in coloration by many specimens in similar prelage from the northern portion of the range of *pennsylvanicus*. In size it is indistinguishable from typical *pennsylvanicus* and considerably larger than *carolinensis*. Consequently, all of Maryland falls within the range of *S. c. pennsylvanicus*, and this range extends at least as far south as Eastville on the Virginia portion of the Delmarva Peninsula and probably as far as the tip of that peninsula.

FOX SQUIRREL

Sciurus niger Linnaeus

[*Sciurus*] *niger* Linnaeus, Syst. nat. ed. 10, 1: 64, 1758.

This is our largest tree squirrel and one of the most spectacular rodents in Maryland. It resembles the gray squirrel but is considerably bigger and heavier, and less often observed. Mansueti (1952, p. 31) comments that a ratio of 40 grays to one fox squirrel may be high, but that few fox squirrels have been reported in recent years and the species appears to be becoming scarce in all the Atlantic Coast States.

The distribution of fox squirrels in Maryland has been reviewed by Mansueti (1952, pp. 31–41), and most of the following is based upon his records or records cited by him.

Two subspecies occur within Maryland. They are:

Sciurus niger cinereus Linnaeus

[*Sciurus*] *cinereus* Linnaeus, Syst. nat., ed. 10, 1: 64, 1758.

Sciurus niger bryanti H. H. Bailey, Bailey Mus. Libr. Nat. Hist., Newport News, Virginia, Bull. No. 1 [p. 1], 1 August 1920. (Type locality: Dorcester County, Md.)

Type locality.—Restricted to Cambridge, Dorchester County, Maryland, by Barkalow (1956, p. 13).

General distribution.—Formerly from Northampton County in Virginia to southeastern Pennsylvania, but now confined to the Eastern Shore section of Maryland. It has been listed by the Department of the Interior as an endangered form.

Distribution in Maryland.—Occurs in limited numbers in Dorchester, Queen Annes, Talbot, Wicomico, Somerset, and Worcester

Counties. The present center of population appears to be in the vicinity of Blackwater National Wildlife Refuge where it is still common. (See fig. 29.)

Distinguishing characteristics.—Teeth 1/1, 0/0, 1/1, 3/3, = 20; coloration uniform light grizzled-gray above with a steel blue cast; belly and feet white; tail with a pronounced black stripe on outer edges. A melanistic form occurs in which the belly and back are blackish. May be readily distinguished from the gray squirrel, which it resembles somewhat in coloration, by its much larger size and reduced dentition.

Measurements.—Five adults from Dorchester County have external measurements as follows: Total length 579 (560–605); tail 273 (263–285); hind foot 77 (73–81). Cranial measurements of four adults from Dorchester County are: Greatest length 68.5 (67.7–69.8); zygomatic breadth 38.8 (37.9–39.8); least interorbital breadth 20.8 (19.4–22.3); length of maxillary toothrow 11.9 (11.8–12.0).

Habitat and habits.—This subspecies prefers mature forests of mixed hardwoods and conifers in which mast-producing trees such as oaks, hickories, and pines are present. It is particularly partial to old-growth loblolly pine forests, many of which, however, have been cut over or burned through forest fires.

This squirrel spends much time on the ground but generally doesn't stray far from the home roost. It lies close to the body of a tree or limb, seldom leaping from tree to tree as does the gray squirrel. Nests, which serve as home during summer and winter, are placed near the tips of branches in old pines, generally from 30 to 50 feet above the ground. Mating may occur at any time throughout the year, but is most frequent during the latter part of February or early March. Usually, four young comprise a litter and are born in April.

Fox squirrels feed more on the ground than do gray squirrels. Food consists primarily of acorns, hickory nuts, walnuts, and particularly the seeds of loblolly pine. They seldom, if ever, cause damage to corn or other domestic crops.

This squirrel has become greatly reduced in numbers and has entirely disappeared from some areas of its former range. One of these areas is the northern portion of the Eastern Shore section; this is the area where this subspecies would be expected to intergrade with *Sciurus niger vulpinus*, the form inhabiting the Western Shore of Maryland.

Specimens examined.—Dorchester County: Airey (near), 1; Blackwater Refuge, 1; Bucktown, 1; Cambridge, 9. *Kent County:* East Neck Island, 3. Eastern Shore (no exact locality), 3.

Other records and reports (with dates of capture or sighting when available).—*Dorchester County:* Big Blackwater Section, 1932, (Dozier and Hall, 1944, p. 5); Gibbs Marsh, between Golden Hill and Church Creek, near Blackwater River (Mansueti, 1952, p. 33); Griffins Neck (Dozier and Hall, 1944, p. 10); Milton (Dozier and Hall, 1944, p. 10); Salem Woods, 14 Miles from Cambridge on road to Salisbury, 1933, (Dozier and Hall, 1944, p. 5); Secretary (Dozier and Hall, 1944, p. 10); Taylors Island, 1963, (James B. Trefethen in correspondence to Bureau of Sport Fisheries and Wildlife, 12 November 1964). *Queen Annes County:* Church Hill (near), 4 miles below Chestertown, 1943, (Dozier and Hall, 1944, p. 3). *Somerset County:* Big Swamp, 2 miles E of Kings Creek, 1922, (Dozier and Hall, 1944, p. 3); Westover, due west of, 1940, (Dozier and Hall, 1944, p. 3); Loretto, near, 1944, (Dozier and Hall, 1944, p. 3). *Talbot County:* Trappe, near, 1948, (Mansueti, 1952, p. 33). *Worcester County:* Newark, 1951, (Mansueti, 1952, p. 33); Pocomoke City, near, (Dozier and Hall, 1944, p. 3).

Sciurus niger vulpinus Gmelin

[*Sciurus*] *vulpinus* Gmelin, Syst. nat., ed. 13, p. 147, 1788 (based on specimens from the eastern United States, including the Blue Mountains of Pennsylvania).

General distribution.—Formerly occurred from central New York, south through south-central Pennsylvania, western Maryland, eastern West Virginia, western Virginia, and in the Appalachian Mountains to western North Carolina. Distribution presently reduced to south-central Pennsylvania, Maryland, western Virginia, and eastern West Virginia.

Distribution in Maryland.—Found locally in heavily forested regions in the Western Shore, Piedmont, Ridge and Valley, and Allegheny Mountain sections.

Distinguishing characteristics.—Similar in size and general characteristics to *S. n. cinereus*, but differs in coloration. The body is generally buffy brown above, in contrast to the bluish grizzled gray of *cinereus;* tail grayish white above, rufous below; feet and ears rufous; top of head more blackish than the back. May be distinguished from the gray squirrel by its larger size.

Measurements.— No external measurements are available for any of the Maryland adults in the National Museum collections. Two adults from White Sulphur Springs, West Virginia, which are typical of this subspecies have the following measurements: Total length 615, 603; tail 299, 298; hind foot 77, 79. Four Maryland specimens (two from Laurel, Prince Georges County; one from Priest Bridge, Anne Arundel County; and one from North Chesapeake Beach, Calvert County) have the following cranial measurements: Greatest length 67.7 (66.6–68.2); zygomatic breadth 38.6 (38.2–39.4); least interor-

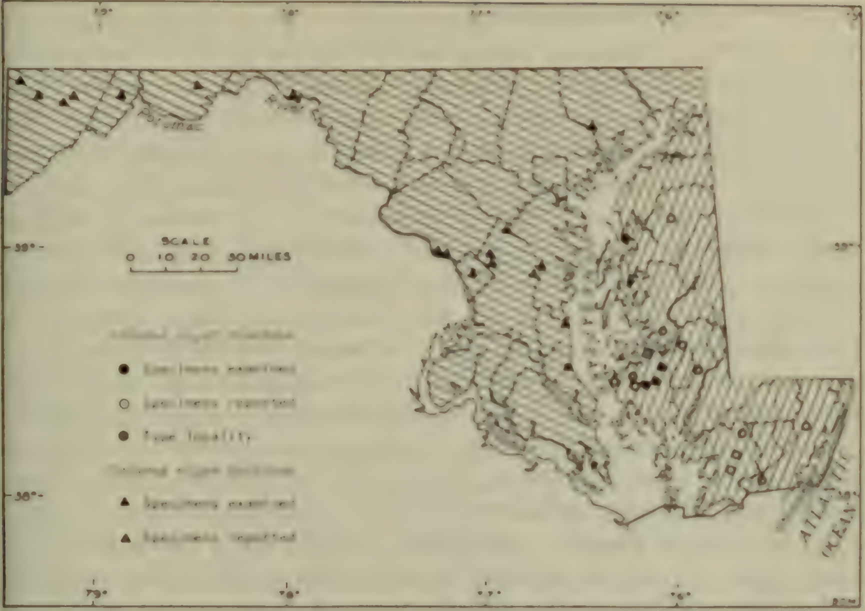

FIGURE 29.—Distribution of *Sciurus niger cinereus* and *S. n. vulpinus*.

bital breadth 20.3 (20.1–20.5); length of maxillary toothrow 11.9 (11.0–12.3).

Habitat and habits.—Not much has been published concerning the habitat and habits of this subspecies. It is said to prefer open deciduous woods, wood borders, and orchards, but as noted by Bailey (1923, p. 110) it is skillful in keeping out of sight. Mansueti (1952, p. 35) states that the subspecies has been considerably decimated in recent years, and the remaining fox squirrels are strictly local in distribution and are more or less relic populations where they occur.

Bailey (1923, p. 110) reported that at various times fox squirrels were released in the National Zoological Park in Washington, D.C. These apparently never flourished, since none have been observed in the park in years.

Specimens examined.—*Allegany County:* Between Clarysville and Red Hill, 1 (Coll. U. Md.). *Anne Arundel County:* Patuxent River at Priest Bridge, 10. *Calvert County:* North Chesapeake Beach, 1. *Garret County:* Friendsville, 1/4 mile NW, 2 (Coll. U. Md.). *Harford County:* Fallston, 1. *Prince Georges County:* Laurel, 4. *District of Columbia:* 4 (these were either purchased at the Central Market or trapped in the National Zoological Park, and probably are not actually from the District of Columbia area).

Other records and reports (from Mansueti, 1952, except where otherwise noted.—*Allegany County:* Green Ridge State Forest, 1935.

Calvert County: Governors Run, 1948 (?). *Garrett County:* Accident 1945 and 1951; Bittinger, 1948; Meadow Mountain, 1947. *Montgomery County:* Great Falls, 1916; Plummers Island (Goldman and Jackson, 1939, p. 133). *Prince Georges County:* Bladensburg (near), 1949 (?). College Park, 1948; 1/2 mile east of intersection of Highways 214 and 301, 1940. *Washington County:* Fort Frederick State Park, 1950.

Remarks.—Mansueti (1952, p. 35) lists on a provisional basis a third subspecies of the fox squirrel in Maryland, the more western *Sciurus n. rufiventer.* He and Vagn Flyger in 1950 examined the tail of a fox squirrel shot on a hill near Storey's Landing, Deep Creek Lake, Garrett County, several years before, and found that its coloration was similar to that of *rufiventer.* This subspecies normally occurs west of the Allegheny Mountains and prefers open or parklike upland woods rather than heavily forested sections. It commonly occurs along fence rows in cultivated fields or in pastures where there are only scattered trees. Mansueti claims that these conditions are found in many parts of Garrett County, particularly around Deep Creek Lake and that *rufiventer* may be moving into this area from further west. He states that possibly as the heavily forested areas are cut, and *S. n. vulpinus* vacates, *S. n. rufiventer* invades the area vacated. On the other hand, he notes that numbers of *S. n. rufiventer* have been released in southwestern Pennsylvania in an effort to restock the area and some of these may have migrated south into Maryland. The two specimens from Garrett County that I have examined, however, are typical *S. n. vulpinus* and exhibit none of the characters of *rufiventer.*

RED SQUIRREL

Tamiasciurus hudsonicus loquax (Bangs)

Sciurus hudsonicus loquax Bangs, Proc. Biol. Soc. Washington, 10: 161, 28 December 1896.

Type locality.—Liberty Hill, Conn.

General distribution.—Southern Ontario, southern Vermont and New Hampshire, south to northern Virginia and West Virginia, west to eastern Iowa and southeastern Minnesota.

Distribution in Maryland.—Occurs locally in the Piedmont, Ridge and Valley, and Allegheny Mountain sections; scarce or absent over most of the Western Shore section; apparently absent in the Eastern Shore section.

Distinguishing characteristics.—Teeth 1/1, 0/0, 2/1, 3/3, = 22; anterior upper premolar frequently lacking, and when present so reduced as to be easily overlooked; size small, the smallest of our local tree squirrels; tail relatively short and bushy; general coloration in winter bright rufous above, white below; ears tufted with black; in summer, coloration more olive dorsally, with ears untufted.

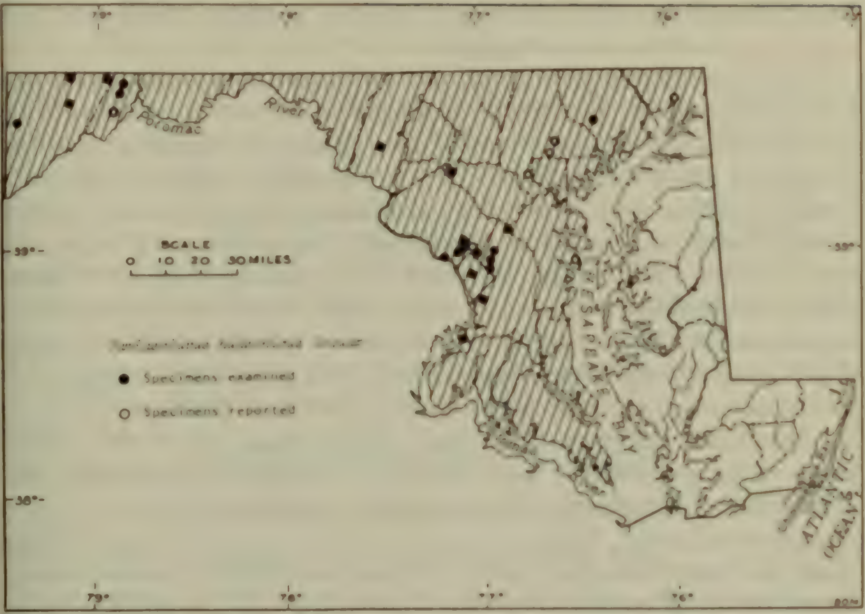

FIGURE 30.—Distribution of *Tamiasciurus hudsonicus loquax*.

This squirrel is differentiated from all others in Maryland by its small size and reddish coloration.

Measurements.—Two adults from the vicinity of Bethesda, Montgomery County, have external measurements as follows: Total length 310, 303; tail 130, 130; hind foot 50, 51; ear 22, 27. Cranial measurements of 10 adults from Laurel, Prince Georges County are: Greatest length 45.2 (44.4–46.0); zygomatic breadth 26.2 (26.0–27.2); least interorbital breadth 13.9 (13.1–14.6); length of maxillary toothrow 7.2 (6.6–7.8).

Habitat and habits.—This squirrel prefers spruce and hemlock forests, but is often found in deciduous woods and in rural areas in the northern hardwoods region where it sometimes builds nests in the attics of houses. It is more terrestrial than the gray squirrel, spending a great deal of time on the ground searching for food. It is also more omnivorous than the gray squirrel, eating almost any kind of seed, nut, or berry. Various kinds of fungi are consumed and even an occasional egg when the nest of a songbird is raided. Hamilton (1943, p. 224) says that it has been known to kill and partially devour young cottontail rabbits.

The bulky nest of the red squirrel, made of grass and moss, is usually placed high in the branches of a tree and can be distinguished from that of the gray squirrel by its smaller size and the finer material used in its construction. The red squirrel is active throughout the year.

It produces litters of from three to six young early in the spring and often a second litter in late summer.

The center of Maryland's red squirrel population is the spruce and hemlock forests of the Allegheny Mountain section of the State. It is scarce or absent over most of the Western Shore section and apparently lacking in the Eastern Shore section. David H. Johnson, formerly Curator of Mammals, U.S. National Museum, tells me that he is very familiar with pine woods near Greenbelt, Prince Georges County, and never observed a red squirrel there. J. C. Lingebach, Division of Mammals, U.S. National Museum, advises me that in his many years of field experience in the Annapolis area of Anne Arundel County he never observed a red squirrel. Flyger (1957, p. 1), however, reports that he trapped a red squirrel on 23 February 1957 near the Naval Academy in Annapolis and that there had been a colony there for several years. This is probably an artificially introduced population. Red squirrels have, however, been taken at such Western Shore section localities as Laurel, Bladensburg, Oxon Hill, Riverdale, and College Park, in Prince Georges County, and Marshall Hall in Charles County. These localities are not very distant from the fall line and the beginning of the Piedmont section, and elsewhere in the Western Shore section the red squirrel appears to be exceedingly scarce.

Even in the Piedmont section the species is only locally abundant, being completely absent over large areas. At one time it was numerous in Rock Creek Park in Washington, D.C., but none have been seen there in recent years. It is still plentiful in some suburban areas northwest of Washington. A lactating female was found dead by David H. Johnson on a road adjacent to a pine woods a few miles northwest of Bethesda, Montgomery County, in October 1955, and another near this general area in September 1957. Johnson tells me that it is the common squirrel in some of the pine woods in the Bethesda area, being more often seen there than gray squirrels. In the Piedmont section of Baltimore County, Hampe (1939, p. 6) reported red squirrels uncommon in the pine woods of the Patapsco State Park, but Bures (1948, p. 67) found that it was a common resident of the Bare Hills–Lake Roland area a few miles to the northeast. Evidently, the red squirrel has a scattered distribution in Maryland and is only abundant locally.

Specimens examined.—Allegany County: Frostburg, 1; Mount Savage, 2 (Coll. U. Md.). *Charles County:* Marshall Hall, 1. *Frederick County:* Middletown, 6. *Garrett County:* Bittinger, 1; Finzel, 2; Grantsville, 1; Swallow Falls State Park, 1. *Harford County:* Fallston, 1. *Howard County:* Long Corner, 1. *Montgomery County:* Bethesda, 3½ miles NW, 1; Bethesda, 5 miles NW, 1; Kensington, 8; Linden, 2; Plummers Island, 1; Takoma Park, 3. *Prince Georges*

County: Bladensburg, 2; College Park (near), 1; Laurel, 16; Oxon Hill, 1; Riverdale, 1. *District of Columbia:* 25.

Other records and reports.—Allegany County: Dans Mountain (Coll. U. Md.). *Anne Arundel County:* Annapolis (Flyger, 1957, p. 1). *Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948, p. 67); Loch Raven (Kolb, 1938); Patapsco State Park (Hampe, 1939, p. 6). *Cecil County:* Northeast (Coll. Acad. Nat. Sci. Philadelphia). *Montgomery County:* Silver Spring (files of U.S. Fish and Wildlife Service). *Prince Georges County:* Hyattsville (Bailey, 1923, p. 107).

Remarks.—Specimens from Garrett County and Allegany County appear somewhat darker in summer and winter pelage than specimens from farther east in the State and may represent intergrades with the southern Appalachian subspecies *T. h. abieticola.*

SOUTHERN FLYING SQUIRREL

Glaucomys volans volans (Linnaeus)

[*Mus*] *volans* Linnaeus, Syst. Nat., ed. 10, 1:63, 1758.

Type locality.—Virginia (fixed by Elliot, Field Columb. Mus., Zool. Ser., 2: 109, 1901).

General distribution.—From central Minnesota, Upper and Lower Peninsulas of Michigan, southeastern Ontario, New York, and southern New Hampshire, south to North Carolina and Tennessee, west to eastern Kansas and Nebraska.

Distribution in Maryland.—Probably abundant in all sections of the State where there is suitable habitat. No specimens or records are available, however, from the Eastern Shore, Ridge and Valley, and Allegheny Mountain sections, but this probably indicates that these sections have not been systematically trapped for the species rather than a scarcity of the animals themselves. Flying squirrels are nocturnal, shy, and seldom observed.

Distinguishing characteristics.—Teeth 1/1, 0/0, 2/1, 3/3, = 22; a small squirrel that is characterized by a "flying membrane", a loose fold of fully furred skin connecting the fore and hind limbs from wrists to ankles. The tail is broad, flattened, and almost parallel-sided, with the tip rounded; pelage extremely soft and dense; coloration of upper parts varies with season and age, but is generally grayish brown; under parts ususally white or creamy white in coloration, with the white extending from the base of the hairs to the tip; dark brown streak extending along side edge of "flying membrane"; tail grayish above, cinnamon below; forefeet white, hind feet brown except for some white on toes.

This species may be distinguished from all other squirrels in Maryland by the distinctive "flying membrane." The northern flying squirrel, *Glaucomys sabrinus*, has not as yet been reported from Maryland,

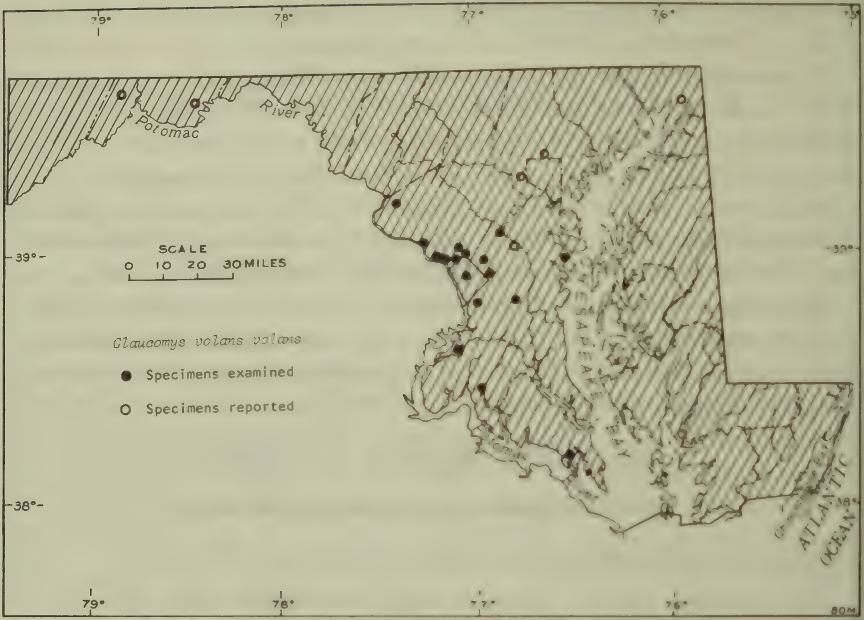

FIGURE 31.—Distribution of *Glaucomys volans volans*.

but may occur in spruce and fir forests in the highest elevations of the Allegheny Mountain section. It differs from the present species primarily in that it is much larger in size and the basal portion of the white hairs of the belly are colored grayish.

Measurements.—External and cranial measurements of eight adults from Newport, Charles County, are as follows: Total length 221.9 (211–240); tail vertebrae 97.9 (90–110); hind foot 26.6 (21–30); greatest length of skull 34.6 (33.5–35.6); zygomatic breadth 20.5 (19.7–21.3); interorbital breadth 6.9 (6.5–7.5); length of maxillary tooth row 6.4 (6.2–6.5).

Habitat and habits.—This is essentially a species of the heavy timber and is never found at any great distance from water. It prefers forests of deciduous trees, but is sometimes encountered in woodlands of mixed conifers and hardwoods. Occasionally it may occupy an old orchard.

The species is probably abundant in all sections of the State where there is suitable habitat, but because of its secretive habits it is seldom noticed. Bures (1948, p. 67) says that in the Bare Hills–Lake Roland area of Baltimore County it is as common as the chipmunk, but because of its nocturnal habits is less often observed. Hampe (1939, p. 6) found that it was fairly common in the Patapsco State Park. He observed one at twilight on 22 May 1936. Bailey (1923, p. 112) found the species common in the woods of the District of Columbia, right up to the edge of the city.

The flying squirrel is one of the most nocturnal mammals in Maryland, rarely leaving its nest before the sun is well down. It remains active throughout the night, foraging for hickory nuts, beechnuts, acorns, maple and wild cherry seeds, apples, and buds and blossoms of some trees. It is carnivorous to some extent and occasionally feeds on insects, young birds, and birds' eggs. This squirrel is highly social.

The favorite nesting site for the flying squirrel is a hole in a dead or dying tree. A cavity made by a woodpecker is often preferred, although occasionally a natural one will be utilized and artificial bird nest boxes are sometimes used. The nest is composed of finely shredded leaves and inner bark.

This species probably does not hibernate in Maryland, although farther north it becomes inactive during colder weather (Sollberger, 1940, p. 285). Mating may occur in late February or early March and the gestation period is about 40 days. Three young usually comprise a litter, and a second mating sometimes occurs in July (Sollberger, 1943, p. 163).

Specimens examined.—Anne Arundel County: Annapolis, 3 miles NW, 1. *Charles County:* Marshall Hall, 2; Newport, 10. *Montgomery County:* Cabin John Creek, 1; Capitol View, 1; Chevy Chase, 1; Dickerson, 1; Garrett Park, 1; Glen Echo Heights, 1; Great Falls, 1; Kensington, 2; Plummers Island (near), 1; Silver Spring, 4. *Prince Georges County:* Anacostia River, NW Branch, 1; Branchville, 1; Laurel, 2; Upper Marlboro, 1; no exact locality, 3. *St. Marys County:* Tall Timbers, 1.

Other records and reports.—Allegany County: Mount Savage (Coll. U. Md.); Town Hill (Coll. U. Md.). *Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948, p. 67); Patapsco State Park (Hampe, 1939, p. 6). *Cecil County:* Bacon Hill (3 specimens in Phila. Acad. Nat. Sci.). *Montgomery County:* Forest Glen (Bangs, 1896, p. 166). *Prince Georges County:* Patuxent Research Center (Herman and Warbach, 1956, p. 87).

Family CASTORIDAE (beavers)

BEAVER

Castor canadensis Kuhl

Castor canadensis Kuhl, Beitr. z. zool. u. vergleich. Anat., Abth. 1, p. 64, 1820.

Type locality.—Hudson Bay.

General distribution.—Formerly ranged over most of the forested regions of North America, north of Mexico. It was exterminated in many areas of its range and later successfully reintroduced into some sections.

Distribution in Maryland.—Formerly occurred in all sections of the State, but was exterminated around the turn of the century or earlier. It has been deliberately restocked in some areas and naturally invaded others from neighboring States where animals were stocked or remnant populations survived.

Distinguishing characteristics.—Teeth 1/1, 0/0, 1/1, 3/3, = 20; largest rodent in Maryland; body thickset and compact; legs short; ears small; hind feet large with the toes webbed; tail broad, flat, nearly hairless, and covered with large scales; pelage with very soft dense underfur, overlaid with long coarse guard hairs; coloration dark rich brown above, lighter below.

Measurements.—"Nine adults from the Allegheny National Forest, Pennsylvania, average: Total length, 1,031 mm. (970–1,090 mm.); tail vertebrae, 358 mm. (260–440 mm.); greatest width of tail, 129 mm. (112–150 mm.); hind foot, 169 mm. (156–183.)." (Handley and Patton, 1947, p. 158).

"The skull is large and massive, that of the adult more than 120 mm. long and 85 mm. broad; . . . length of upper molar series about 28 to 30 mm." (Jackson, 1961, p. 192).

Habitat and habits.—This species prefers forested areas wherever there are suitable watercourses for the construction of dams and lodges. The sluggish fresh-water streams of the Eastern Shore section are especially suited to their needs.

The beaver feeds on a wide range of plants. These may be sedges, rushes, water grasses, various roots and tubers, and bark, leaves, and twigs of bushes and trees. In winter it feeds primarily on green branches that it stores under water near the lodge. In Maryland its favorite trees appear to be sweetgum, pine, ash, dogwood, oak, and maple.

These animals are monogamous, and it is believed that they mate for life. Breeding begins about mid-January and extends to the end of February. The gestation period is approximately 120 days, and a single litter of from one to eight kits is produced a year (the most frequent number being four or five).

The beaver's most important activity is felling trees for dams and lodges. A large beaver lodge is about 5 to 6 feet high and 15 or 20 feet wide at the water level. More often, however, smaller lodges are built, some 3 to 4 feet in height and 8 to 10 feet in diameter. The inside of a lodge consists of one room about 2 to 3 feet in height, and as many as 8 to 10 beaver may occupy it. The opening to the lodge is always under water. Many beavers, however, that inhabit lakes or deep streams live in bank dens rather than constructing lodges and dams.

The beaver is active throughout the year, but is seldom active during daylight hours. Its routine workday begins at dusk and ends at dawn.

Young beavers in their second year leave the parental colonies and emigrate to establish themselves in new colonies by pairs. Sometimes they may move as much as 30 miles to a new home. Most of this movement is accomplished in the water, because the animal is quite clumsy and slow moving on land.

According to Mansueti (1950, p. 33) no one knows when Maryland's native beavers were finally exterminated. He judges that on the basis of when they disappeared in Pennsylvania and New Jersey, they probably were gone from the Maryland lowlands about 150 years ago and that there were probably some native beavers left in western Maryland less than 100 years ago. Their extirpation was due to a number of reasons, the primary ones being heavy trapping pressure for their pelts, and elimination of suitable habitat. Beaver have reappeared in Maryland in recent years either through deliberate introductions or as a result of their natural migrations from other states where they had not been entirely extirpated or had been stocked. They are flourishing now in certain areas, presumably because low pelt value makes trapping unprofitable in the State.

Recent records and reports.—Bonwill and Owens (1939, pp. 36–37) mention 3 areas of Maryland where these animals were thriving in 1939. One was on the Upper Potomac River near Gormania, Garrett County; the second on Town Creek in Allegany County; and the third at a point where the Andover and Sewell Creeks meet at the head of the Chester River in Kent County. They believe that the first two colonies were the result of migrations from colonies in Pennsylvania or West Virginia that had escaped extermination in those States or had been reintroduced there. The Kent County colony was a result of migration from a colony in Delaware which had been stocked with animals from Maine by the Delaware Board of Game and Fish Commissioners in 1935.

Arner (1949, p. 23) says that the beaver migrated into the western Maryland Counties of Garrett and Allegany from colonies in West Virginia and are firmly established in eight streams in Garrett County and three streams in Allegany. They may be found in Garrett County in the Youghiogheny River, Laurel Run, Harrington Creek, and Broad Ford Run. In Allegany County they inhabit Evitts Creek and Town Creek; and beaver cuttings have been found on Sideling Hill in Washington County. He estimates that in 1949 there were 150 beavers in western Maryland.

Remarks.—Authorities are in agreement that Maryland's native beaver population probably represented the subspecies *C. c. canadensis*. It is impossible to assign subspecific rank to Maryland's present beaver population since they come from so many different sources, and even some of the areas from which they have been stocked were themselves stocked at an earlier period with animals from elsewhere. No specimens of the native population or the present population of beavers have been available to me for examination.

Family CRICETIDAE (deer mice, harvest mice, voles, etc.)

MARSH RICE RAT

Oryzomys palustris palustris (Harlan)

Mus palustris Harlan, Silliman's Amer. Jour. Sci., 31: 385, 1837.

Type locality.—"Fast Land" near Salem, Salem County, N.J.

General distribution.—In the Coastal Plain from southeastern Pennsylvania and southern New Jersey, south to northern Florida, west to the Mississippi River and north in the Mississippi Valley to southeastern Missouri, southern Illinois, and central Kentucky.

Distribution in Maryland.—Recorded only from the Eastern Shore and Western Shore sections.

Distinguishing characteristics.—Teeth 1/1. 0/0, 0/0, 3/3, = 16; ratlike in general appearance, but considerably smaller than adult Norway rat; tail long, nearly half the total length; fur long and coarse; color of upper parts grizzled grayish brown, mixed with blackish, sides paler with less blackish; underparts white to pale buff; tail sparsely haired and scaly, brownish above and whitish below. Young animals are more grayish than adults.

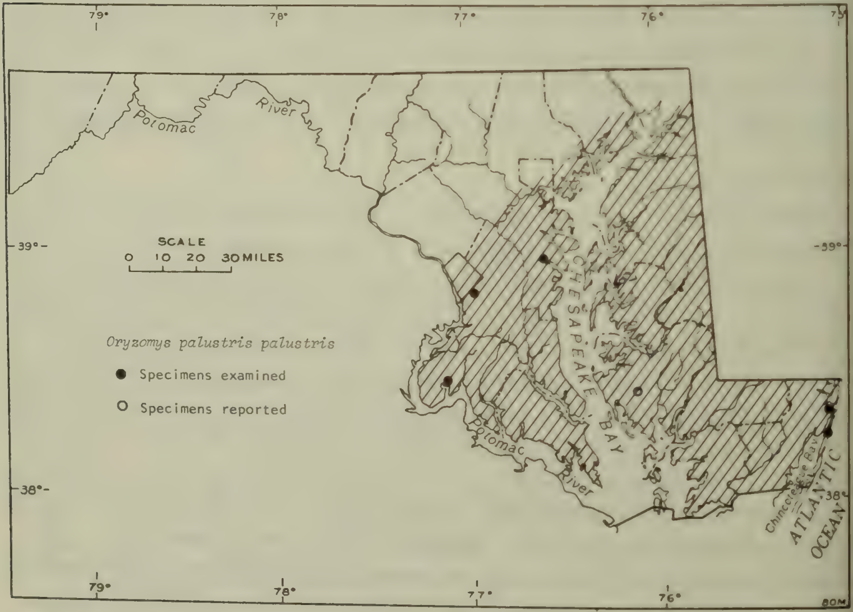

FIGURE 32.—Distribution of *Oryzomys palustris palustris.*

Marsh rice rats superficially resemble young Norway rats from which they may be distinguished by the upper cheek teeth. These teeth have two longitudinal rows of tubercles in rice rats; in Norway rats there are three such rows.

Measurements.—An average-sized female from West Ocean City, Worcester County, has measurements as follows: Total length 247; tail 120; hind foot 30; ear 10; greatest length of skull 30.4; zygomatic breadth 16.4; interorbital breadth 4.9; length of upper molar toothrow 4.4.

An adult female from Nanjemoy Creek, Charles County, has the following external measurements: Total length 262; tail 127; hind foot 30.

There is a peculiar size variation often encountered in this species. Males and females generally average about the same size, but often an apparently adult female may be strikingly smaller than the average.

Habitat and habits.—This species is partially amphibious and shows a great preference for wet meadows, marshy areas, watercourses, cane breaks, and swamps, and is only rarely encountered in dry fields.

Marsh rice rats are polyestrous and breed from March to November in Maryland (Harris, 1953, p. 485). The gestation period is 25 days and the female mates again immediately after parturition. Litter size varies from one to five with the average being three.

This species is an accomplished swimmer and does not hesitate to dive and swim under water for great distances when alarmed. It makes nests of grasses and weeds which may be placed under a mass of tangled debris or woven into the rushes a foot or more above the high water level. Its presence may usually be detected by the extensive and well-defined runways it makes and by the mats of cut vegetation floating at irregular intervals in the tidal waters. Sometimes, however, there may be little evidence of rice rats in an area. Harris (1953, p. 481) says that in the Blackwater National Wildlife Refuge in Dorchester County 40 percent of the 86 rice rat captures were made at trap stations showing no signs of small mammals, but some were taken at muskrat houses. Also, he was never able to locate any rice rat nests in this area, and noted that only a few of the runways found might have been made by this species. Rice rats are primarily nocturnal, and Harris states that only rarely was this species observed in the daytime.

In Maryland, rice rats are confined in distribution to the fresh and salt water marshes of the Western Shore and Eastern Shore sections. They seem to be particularly numerous in the fresh, brackish, and salt water marshes of the lower Eastern Shore section and occur in great numbers on Assateague Island, where they occupy the wetter portions of these marshes.

Specimens examined.—Anne Arundel County: South River, at U.S. Route 50, 1. *Charles County:* Nanjemoy Creek, 5. *Prince Georges County:* Oxon Hill, 2 miles NW, 2. *Worcester County:* Ocean City, 4 and 5 miles S (Assateague Island), 2; West Ocean City, 4.

Other records and reports.—Dorchester County: Blackwater National Wildlife Refuge (Harris, 1953).

EASTERN HARVEST MOUSE

Reithrodontomys humulis virginianus A. H. Howell

Reithrodontomys humulis virginianus A. H. Howell, Jour. Mammal., 21 (3) : 346, 13 August 1940.

Type locality.—Amelia, Va.

General distribution.—Known from central Virginia north to Maryland. Exact northern limits of range unknown.

Distribution in Maryland.—Rare in Maryland; probably occurs only in the Western Shore and southern Piedmont sections.

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; upper incisors with conspicuous grooves; mouselike in form; tail about half total length; coloration grayish-brown above with a distinct band of blackish along the median line; sides of head and body paler, more or less washed with light pinkish cinnamon, this color forming a definite lateral line next to the belly; underparts grayish white; tail bicolored, fuscous above, grayish white below; ears fuscous, feet white.

This species closely resembles the house mouse (*Mus musculus*) in general appearance, but may readily be distinguished from that species by the deeply grooved upper incisors. In the eastern United States the harvest mouse is the only long-tailed cricetine rodent with grooved incisors.

Measurements.—An adult female from Takoma Park (near Riggs Mill), Prince Georges County, measures as follows: Total length 132; tail 59; hind foot 15.5; ear 12; greatest length of skull 20.0; zygomatic breadth 10.1; least interorbital breadth 2.9; upper molar toothrow 2.5.

Howell (1940, p. 346) gives external measurements of 10 specimens from the type locality as follows: Total length 117.2 (110–125); tail vertebrae 51.8 (45–56); hind foot 16.2. The greatest length of skull of these 10 specimens is 18.7 (18.3–19.1). It can be seen that the Maryland specimen is considerably larger both externally and in the greatest length of the skull than topotypes of the subspecies from Amelia, Va.

Habitat and habits.—The harvest mouse prefers nonforested land, particularly cultivated fields where grain crops are growing. It seems to be equally at home in dry fields or in bogs, provided there is thick growth of tall grasses or sedges.

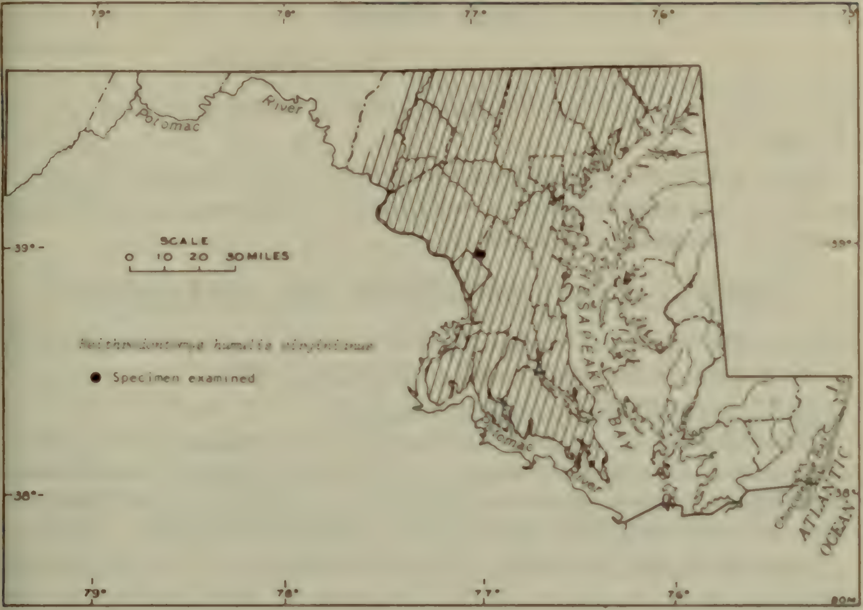

FIGURE 33.—Distribution of *Reithrodontomys humulis virginianus.*

Little is known of the habits of this species. It lives in the cover of grass, weeds, and grains where it makes little runways over the surface of the ground. According to Lewis (1940, p. 426), in Amelia County, Va., it generally makes nests of fine grass blades on top of the ground in tall grass or sedges. These nests are globular and average larger than a croquet ball.

The breeding season is from May to November; the number of young from one to five; the gestation period is about 23 days.

The food of the eastern harvest mouse consists largely of seeds and grains with considerable green vegetation and occasionally fruit (Howell, 1914, p. 11).

According to Bailey (1923, p. 118), many skulls of harvest mice were found in owl pellets in the Smithsonian tower in Washington, D.C. The owl, or owls, however, may have been feeding in nearby Virginia and thus the skulls may not represent District of Columbia or Maryland records. This rodent species has been trapped at only one locality in Maryland.

Specimens examined.—Prince Georges County: Takoma Park (near Riggs Mill), 1. Howell (1940, p. 346), reported examining two specimens from Riggs Mill, and records in the files of the U.S. Fish and Wildlife Service indicate that Ray Greenfield actually took three specimens in that same area on 26 January 1934. Only one specimen from that locality, however, is now in the National collections.

DEER MOUSE

Peromyscus maniculatus (Wagner)

Hesperomys maniculatus Wagner, Arch. Naturgesch., Jahrg. 11, 1: 148, 1845.

This is a wide-ranging species that occurs over much of North America. Numerous subspecies have been described; of these, two are known to occur in Maryland. They are:

Peromyscus maniculatus bairdii (Hoy and Kennicott)

Mus bairdii Hoy and Kennicott, in Kennicott, Agricultural Report, U.S. Commissioners Patents, 1856, p. 92, 1897.

Type locality.—Bloomington, McLean County, Ill.

General distribution.—Prairie region of the upper Mississippi Valley, from eastern Kansas and Missouri; north to southwestern Manitoba, Canada; eastward through southern Minnesota, Wisconsin, and Michigan to the man-made prairie of central New York, Pennsylvania, Maryland, and northern Virginia.

Distribution in Maryland.—The distribution of this subspecies within the State is unknown. It has been taken in Maryland only at the Patuxent Research Center, Prince Georges County. (See fig. 34.)

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; coloration of upperparts brownish gray, mixed with darker hairs; underparts white, the basal gray of the underfur often conspicuous; tail short and distinctly bicolored, upperparts brownish black, white beneath; feet white. Immature animals are more grayish dorsally.

This subspecies is readily distinguished from *Peromyscus maniculatus nubiterrae* by its much shorter tail. It is easily confused with *Peromyscus leucopus*, but may be distinguished by several characters which are discussed under that species.

Measurements.—External measurements of two adults from the Patuxent Research Center, Prince Georges County, (a wild-caught female and one of her laboratory-raised offspring) are as follows: Total length 152, 149; tail 63, 59; hind foot 18, 19; ear 13.5, 14.0. Cranial measurements of three adults from the Patuxent Research Center (the wild-caught female and two of her laboratory-raised offspring) are: Greatest length 23.1, 23.3, 23.0; zygomatic breadth 11.5, 12.1, 11.9; interorbital breadth 3.7, 3.9, 3.9; length of maxillary toothrow 3.0, 3.3, 3.3.

Habitat and habits.—This subspecies inhabits prairies, open fields, and arable land and is entirely absent from dense forests. It was unknown in Maryland until 1949, when Lucille F. Stickel and Oscar Warbach live-trapped several in crop fields at the Patuxent Research Center. These fields are about 1.9 miles north of Bowie and are situated on a wide bench of sandy clay near the Patuxent River. From May

1949 to June 1950, 23 of these mice were captured by Stickel and Warbach.

According to W. H. Stickel (1951, p. 26) the Maryland specimens of this race were most often caught in corn and in young wheat; only occasionally were they found in hay or tall wheat. He says that the subspecies seems to be precariously established at the Patuxent Research Center and was not common, nor did the numbers appear to increase, during the year the area was extensively studied.

Peromyscus m. bairdii is essentially a subspecies of the prairie region of the upper Mississippi Valley. In recent years it appears to have been extending its range eastward consequent with the deforestation of wide areas of land in the eastern United States. In 1909, Osgood (1909, p. 79) knew it only from as far east as Ohio. In 1934, Mitchell (1934, p. 71) recorded it from Meadville, Pa., and in 1938, Moulthrop (1938, p. 503) listed it from Elba, Genesee County, N.Y. Hamilton (1950, p. 100) recorded the first appearance of *bairdii* in 1947 at Ithaca, N.Y., an area that had been heavily trapped for the previous 20 years, and mentioned the capture of the subspecies at North Harrisburg, Dauphin County, Pa., the first record from east of the Appalachian Mountains. More recently, Peacock and Peacock (1962, p. 98) have taken specimens from the area being developed into Dulles Airport, near Chantilly, Fairfax County, Va.

Stickel (1951, p. 26) states that no doubt the animal is expanding its range by natural means in consequence of artificially created habitats, but the possibility of accidental transportation is considerable. It may be that the mouse has succeeded in crossing the heavily forested Appalachian Mountains by following the grass-lined banks and shoulders that line the roads in that area. It would in this way remain ecologically separated from *Peromyscus m. nubiterrae*, the race inhabiting the dense forests of the Appalachians.

Just how widely *bairdii* is distributed in Maryland is unknown. No additional specimens have been taken since Stickel and Warbach collected those at the Patuxent Research Center in 1939. I have trapped many cultivated fields in central Maryland and grassy roadsides in the western part of the State with the hope of obtaining additional records, but without success. The recent records from nearby Chantilly, Va., however, lead me to believe that the subspecies is probably widely distributed, although perhaps scarce as regards total numbers, in open fields throughout Maryland.

These mice feed largely on seeds, grain, and the ripe heads of grasses; berries and numerous insects are also consumed. The nest is built slightly underground, or on the surface, and usually placed under some object, such as a board, fallen tree limb, rock, or old pasteboard carton. The breeding season generally begins in early March and extends through November. A female may breed three or four times yearly, and a litter may contain from two to nine young, although four to six is the most common number.

Specimens examined.—Prince Georges County: Patuxent Research Center, 3.

Peromyscus maniculatus nubiterrae Rhoads

Peromyscus leucopus nubiterrae Rhoads, Proc. Acad. Nat. Sci. Philadelphia, 48: 187, April 1896.

Type locality.—Summit of Roan Mountain, Mitchell County, North Carolina. Altitude 6,370 feet.

General distribution.—Allegheny and Blue Ridge Mountains and adjacent ranges from western Pennsylvania and New York, south to western North Carolina and northeastern Georgia.

Distribution in Maryland.—Found in the Allegheny Mountain section at elevations usually above 2,500 feet.

Distinguishing characteristics.—Similar in coloration and size to *P. m. bairdii*, but is readily distinguished from that subspecies by its much longer tail, which is more than half the total length of the animal. Usually *nubiterrae* has larger ears and feet than *bairdii.*

In general, *nubiterrae* can be distinguished from *Peromyscus leucopus* by certain subtle differences in coloration. Some specimens of *nubiterrae*, however, are confusingly similar to *Peromyscus leucopus*,

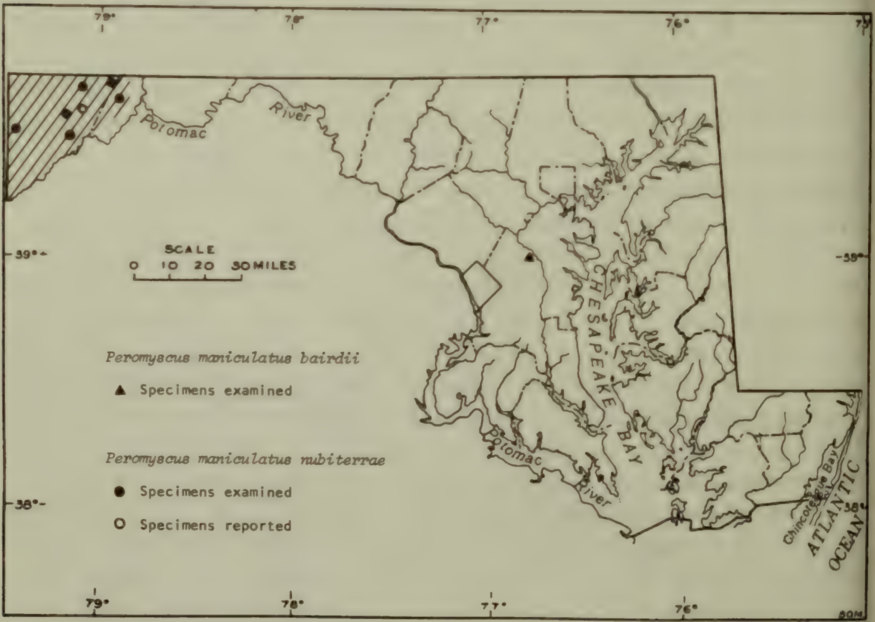

FIGURE 34.—Distribution of *Peromyscus maniculatus nubiterrae* and *P. m. bairdii.*

and their distinguishing characteristics are discussed in more detail under that species.

Measurements.—Thirteen adults from Finzel, Garrett County, have external measurements as follows: Total length 179.3 (172–190); tail 93.1 (82–102); hind foot 20.5 (20–22). Eleven adults from Finzel have the following cranial measurements: Greatest length 24.6 (24.3–25.3); zygomatic breadth 12.3 (11.7–13.3); interorbital breadth 3.7 (3.5–3.9); maxillary toothrow 3.3 (3.2–3.5).

Habitat and habits.—This subspecies prefers dense woods and is most abundant among mossy boulders and logs in moist spruce and fir forests at higher elevations. E. A. Preble (in field notes) gives information about where he took specimens in Garrett County. He says that they were common in a tract of hemlock woods about 3 miles east of Grantsville. One specimen was taken in a small strip of deciduous trees and shrubs adjoining a field where *Peromyscus leucopus* was also taken. At Finzel, at an elevation of about 2,600 feet, he found that these mice were abundant and inhabiting all sorts of situations from the dry hillsides and edges of fields to the deep hemlock swamps, while at Bittinger (elevation about 2,600 feet) they were abundant only in the deep woods.

This mouse nests in burrows under rocks and logs and sometimes in hollow trees. It is somewhat arboreal and may build tree nests as high as 50 feet above the ground (J. W. Bailey, 1946, p. 216). Two or three litters, of from two to seven young, are produced each season. Food consists of seeds, nuts, and berries, supplemented with insects, snails, and occasionally dead birds and other mice.

Specimens examined.—Allegany County: Frostburg, 1. *Garrett County:* Bittinger, 6; Finzel, 18; Grantsville, 16; Swallow Falls State Forest (near Muddy Creek Falls), 1.

Other records and reports.—Garrett County: New Germany (Coll. Nat. Hist. Soc. Maryland).

WHITE-FOOTED MOUSE

Peromyscus leucopus noveboracensis (Fisher)

[*Mus. sylvaticus*] *noveboracensis* Fisher, Synopsis Mammalium, p. 318, 1829.

Type locality.—New York.

General distribution.—From eastern and southern Ontario, east to Maine, south along the Atlantic coast into Virginia, West Virginia, and northern Kentucky, westward, south of Great Lakes, to eastern North Dakota, South Dakota, Nebraska, northeastern Oklahoma, and northwestern Arkansas.

Distribution in Maryland.—Occurs abundantly in all sections of the State.

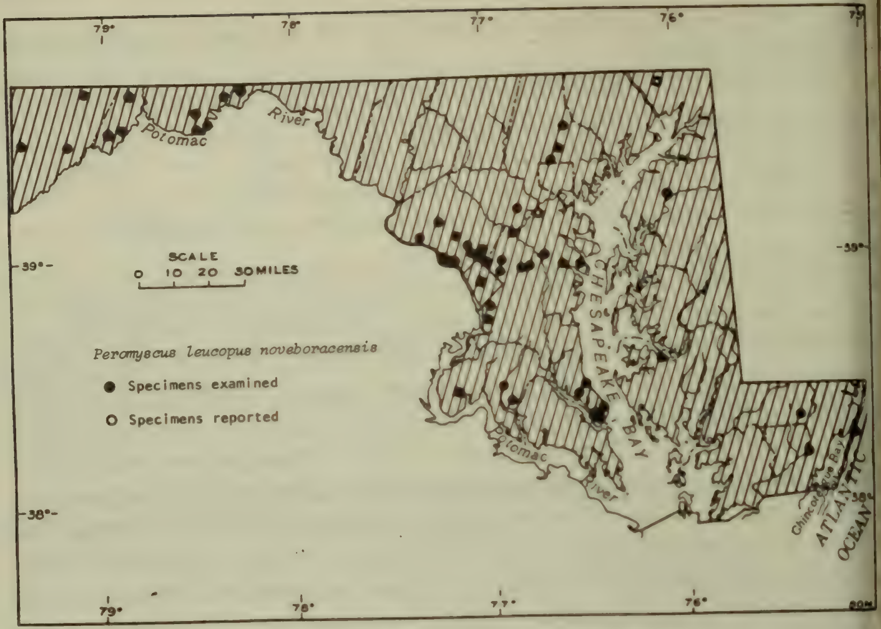

FIGURE 35.—Distribution of *Peromyscus leucopus noveboracensis.*

Distinguishing characteristics.—The white-footed mouse closely resembles the deer mouse (*Peromyscus maniculatus*), from which it may be distinguished as follows:

From *Peromyscus m. bairdii* it differs in being larger, longer tailed, lighter and more brightly colored with more reddish on sides and back, and in having noticeably larger ears and feet; the tail is less distinctly bicolored.

Cranially, *P. l. noveboracensis* is larger than *P. m. bairdii*, and the incisive foramina are differently shaped. These foramina are anteriorly constricted in *noveboracensis*, and open and evenly curved in *bairdii.* A detailed comparison of these two forms is given by Stickel (1951, p. 25–32).

From *Peromyscus m. nubiterrae*, *P. l. noveboracensis* differs in being larger, shorter tailed, (tail less than half the total length of the animal) and more brightly colored, with more reddish on sides and back. This color difference is subtle in individual specimens but becomes apparent when large series of both species are examined. The tail in *noveboracensis* is less distinctly bicolored than in *nubiterrae.*

Some specimens of *nubiterrae* and *leucopus* are so similar in external characteristics that only by a detailed examination of the skull can they be separated. The skull of *nubiterrae* is slender and elongated, the braincase considerably flattened, whereas cranially *noveboracensis* is broader and heavier with the braincase more inflated. As in *P. m.*

bairdii, the incisive foramina of *nubiterrae* are open and evenly curved, while in *noveboracensis* they are anteriorly constricted. The teeth in he latter form, even in juvenile animals, are noticeably larger and more robust than in *nubiterrae*.

Measurements.—External measurements of eight adults from Allegany County (Dans Mountain State Park, and vicinity of Oldtown) are as follows: Total length 174.4 (170–188); tail 76.2 (70–92); hind foot 21.1 (20–22); ear 15.7 (13–18). Nine adults from the same localities have the following cranial measurements: Greatest length 26.2 (26.0–26.7); zygomatic breadth 13.4 (12.7–14.0); interorbital breadth 4.1 (3.9–4.3); maxillary toothrow 3.6 (3.4–3.8).

Habitat and habits.—This species is primarily a woodland inhabitant, but is often found in brushy regions and sometimes in grassy areas that border woodlands. It is one of the most abundant mammals in Maryland. On Assateague Island their tracks have been observed even on the bare sand dunes a few yards from the ocean beach. Usually, however, this mouse will be found not more than 50 feet from woods or forests, of which it seems to prefer the deciduous woods, especially oak-hickory forest.

Nests are built almost anywhere. Although it apparently does not dig its own burrow, or make a trail, this mouse will utilize burrows or trails of other small mammals. Jackson (1961, p. 218) says that it seems to prefer a tree site for its nest, usually about 6 to 8 feet from the ground, but that he has found them in abandoned squirrel nests as high as 20 feet above ground. He says that often the nest is built in a hollow tree or limb, and that another favorite site is under an old stump or log. The nest itself is composed of soft material such as grass, leaves, or other vegetation. It is usually about 10 or 12 inches in diameter and 6 or 8 inches deep.

Breeding takes place in late February or early March, and the first litter is born in April. The gestation period is variable, but is usually between 23 and 25 days, and the litter size varies from one to seven, usually three to six, with four the most frequent number. Each female may produce as many as four litters during the breeding season.

The principal food for the species is seeds of various grasses, weeds, clover, small fruits, and grain as well as acorns and hickory nuts. Insects form a small portion of the diet as does green herbage. This mouse sometimes occupies houses, where it may be bothersome. On Assateague Island in 1957 and 1958, white-footed mice were inhabiting the houses and outbuildings, while house mice (*Mus musculus*) occurred in the woods and marshes, but apparently not in the houses.

Specimens examined.—*Allegany County:* Dans Mountain State Park, 13; Green Ridge, 4; Mount Savage, 11; Oldtown, 4 miles E, 31; Oldtown, 9 miles E, 12; Rawlings, 2; Sideling Hill Creek, 8. *Anne Arundel County:* Annapolis, 3 miles NW, 12; Priest Bridge, 4; South River (at U.S. Route 50), 10. *Baltimore County:* Lake Roland, 5; Loch Raven, 7; Notch Cliff, 1. *Calvert County:* Battle Creek (Cypress Swamp), 4; Cove Point, 3; Drum Point, 2; Scientist Cliffs, 1; Solomons, 2; Solomons, 3½ miles N, 17. *Charles County:* Nanjemoy Creek, 2; Newport, 6; Zekiah Swamp, 4. *Dorchester County:* Cambridge, 5. *Garrett County:* Cranberry Swamp, 7; Grantsville, 4; Swallow Falls, 2 miles S, 2; Swanton, 3. *Howard County:* Atholton, 6. *Montgomery County:* Burnt Mills, 2; Cabin John (vicinity of), 4; Cupids Bower Island (vicinity of), 5; Forest Glen, 1; Great Falls, 1; Kensington, 5; Linden, 2; Plummers Island, 4; Rockville (vicinity of), 6; Seneca Creek (at Clopper Road), 5; Silver Spring, 26; Takoma Park, 1; Woodside, 1. *Prince Georges County:* Anacostia River, NW Branch, 3; Bladensburg, 7; Branchville, 2; Broad Creek (Indian Head Bluff), 4; Collingwood (= Collington?) 1 mile S, 2; Hyattsville, 4; Lanham, 4; Laurel, 10; Oxon Hill, 12; Riggs Mill, 1; Riverdale, 3. *Washington County:* Bear Creek, just N of U.S. Route 40, 2. *Wicomico County:* Powellsville, 1. *Worcester County:* Snow Hill, 1 mile NE, 1; Ocean City, 5 miles S, 1. *District of Columbia:* 62.

Other records and reports.—Allegany County: LaVale (Coll. U. Md.). *Anne Arundel County:* Dorsey (U.S. Fish and Wildlife Service files). *Cecil County:* Rising Sun (U.S. Fish and Wildlife Service files). *Garrett County:* Muddy Creek Falls (Mansueti and Flyger, 1952, p. 250). *Kent County:* Chestertown (U.S. Fish and Wildlife Service files). *Prince Georges County:* Bowie (Lucille F. Stickel, 1946, p. 301).

Remarks.—Specimens from the Eastern Shore section (Cambridge, Powellsville, Snow Hill, and Assateague Island), as well as Virginia specimens from Accomack and Northampton Counties on the lower Delmarva Peninsula, are not typical *noveboracensis* but are somewhat darker in coloration, and smaller in size, and appear to be intergrades with *P. l. leucopus* (Rafinesque). The type locality of *P. l. leucopus* is in western Kentucky, which is also an area of intergradation. Maryland specimens from the Eastern Shore section are only slightly larger and paler than specimens from western Kentucky near the type locality of *P. l. leucopus.* Nevertheless, they are considerably different from *P. l. leucopus* from southern Louisiana (where the subspecies is best characterized) both in size and coloration, and are more closely related to *P. l. noveboracensis* from central New England where *noveboracensis* is best characterized) than to Louisianan *P. l. leucopus.*

EASTERN WOOD RAT

Neotoma floridana magister Baird

N[*eotoma*]. *magister* Baird, Mammals, in Repts. Expl. Surv. . . , 8 (1) : 498, 14 July 1858.

Type locality.—Cave near Carlisle, Cumberland County, or near Harrisburg, Dauphin County, Pa.

General distribution.—Appalachian Mountain region, from extreme western Connecticut and southern New York, south through western Virginia and Tennessee to the Tennessee River in northern Alabama, west to central Kentucky and northward to extreme southern Indiana.

Distribution in Maryland.—The Allegheny Mountain and Ridge and Valley sections; occurs east of the Blue Ridge Mountains in the Piedmont section along the cliffs and bluffs of the Potomac River to the vicinity of Washington, D.C. It may occur among the cliffs and bluffs of river valleys elsewhere in the Piedmont section.

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; size large; coloration grizzled grayish dorsally, with some buffy intermixture, paler and more buffy on sides; underparts and feet white; ears large and naked; tail long, hairy, and distinctly bicolored, black dorsally and white underneath; vibrissae very long, and black or white in coloration. The young are similar to the adults, but are grayer.

This species may be confused with the Norway rat, which it resembles superficially. It may be distinguished from that species by its larger naked ears, its much longer vibrissae, its longer, more hairy, and bicolored tail, and its softer, more grizzled grayish coloration. In addition, the molar teeth of the two species differ. In the eastern wood rat the crowns are flat, with the enamel thrown into prismatic folds; in the Norway rat the molars are tuberculate.

Measurements.—An adult male from 9 miles E of Oldtown, Allegany County, measures as follows: Total length 430; tail 188; hind foot 42; ear 30; greatest length of skull 56.2; interorbital breadth 6.8; length of nasals 21.5; length of molar toothrow 9.3.

Hamilton (1943, p. 306) gives the following external measurements for 10 adults from New York, Pennsylvania, and West Virginia: Total length 423 (405–441); tail 186 (170–200); hind foot 43.5 (40–46).

Habitat and habits.—The eastern wood rat prefers cliffs, rock slides, caves, and bare patches in the mountainous regions of the State. It ranges into the Piedmont section at least in the Potomac River Valley, where it lives in the cliffs and rocks that border the river. It may occur in the bluffs that border other rivers in the Piedmont section, and has been reported from Woodside, Montgomery County (Wetmore, 1923, p. 187). In the Potomac River Valley, it has been found as far south

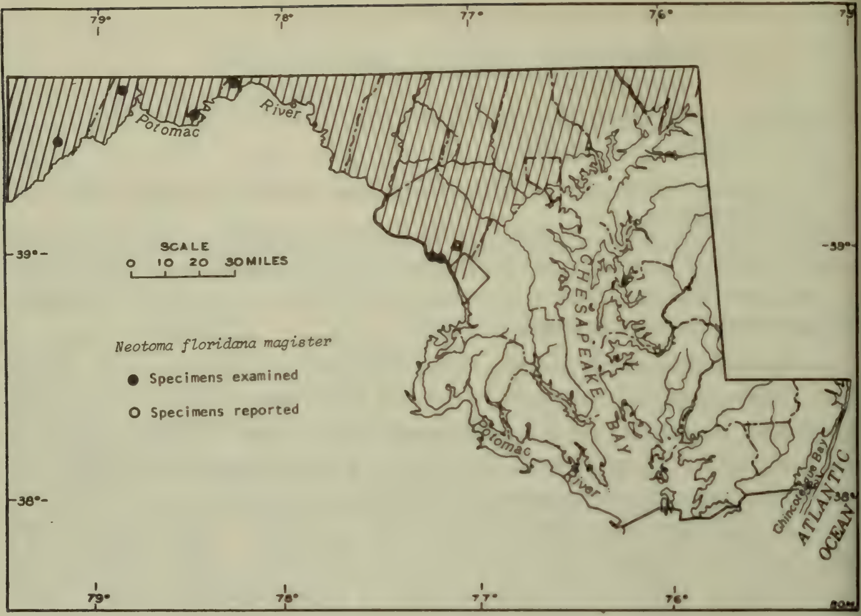

FIGURE 36.—Distribution of *Neotoma floridana magister.*

as Plummers Island, Montgomery County, and on the Virginia side of the river at Chain Bridge.

Wood rats were particularly abundant in the vicinity of Oldtown, Allegany County, in the fall of 1961, where virtually every rocky outcropping contained signs of them. They had taken up residence under the front porch of a hunting cabin 9 miles east of Oldtown, and the sounds of their activity could be heard all night. They are inquisitive animals, and one had thoroughly explored an automobile that was parked nearby, even crawling into the engine compartment, leaving tracks everywhere in the dust.

The eastern wood rat appears to have moved into Maryland's Piedmont section only within recent years. Wetmore (1923, p. 187) reports that although Plummers Island had been under observation by Washington naturalists since 1902, it wasn't until 1921 that the species was discovered to be resident there. It was known, however, to inhabit the cliffs along the Virginia side of the Potomac River as far south as Chain Bridge for many years before it was first reported from Plummers Island, and it seems probable that the Plummers Island population crossed over from Virginia during a winter when the Potomac was frozen over. Wetmore (1923) says that one was killed on Plummers Island on 25 June 1921, by Mr. W. R. Maxon, but was not preserved. On 26 September and 15 October 1921, two specimens were collected and preserved in the Biological Survey collection. In the same year, five nests of this species were discovered beneath the cabin on the island.

Wetmore (1923) describes the nests of the eastern wood rat on Plummers Island as being composed of bits of finely shredded cedar bark and similar materials that formed a flattened mass 12 to 15 inches across with a small depression in the center. As it was warm weather the cavities were open above, but the walls were so arranged that they could be pulled out to form a domed covering if the need for greater warmth arose.

Wood rats eat practically any vegetation they can obtain, including fruits and berries, fungi, ferns, rhododendron, and a host of others. The species breeds from spring until fall, and as many as three broods may be raised annually. The gestation period is 30 to 36 days, and one to three young are usually born.

Specimens examined.—Allegany County: Mount Savage, 1 (Coll. U. Md.); Oldtown, 9 miles E, 1. *Garrett County:* Backbone Mountain, Savage River Dam Site, 2 (Coll. U. Md.). *Montgomery County:* Plummers Island, 2. *Washington County:* Bear Creek, just north of U.S. 40, 1 (Coll. U. Md.).

Other records and reports.—Montgomery County: Perry's Island (Wetmore, 1923: 187); Woodside (Wetmore, 1923: 187).

RED-BACKED MOUSE

Clethrionomys gapperi gapperi (Vigors)

Arvicola gapperi Vigors, Zool. Jour., 5: 204, 1830.

Type locality.—Between York [Toronto] and Lake Simcoe, Ontario, Canada.

General distribution.—Massachusetts south in the Appalachians to western Virginia and west through New York, northern Michigan, and southern Ontario to eastern Minnesota.

Distribution in Maryland.—Occurs on the cooler forested slopes in the Ridge and Valley and Allegheny Mountain sections.

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; cheek teeth rooted in adults; size medium; coloration of upper parts rusty red, becoming buffy on the sides and around the face; underparts buffy white; tail less than a third of total length of animal, and bicolored, blackish above, paler below.

This mouse may be distinguished from most other Maryland mice by its reddish coloration and short tail. It resembles the pine mouse, however, in both these characters, but differs in that the reddish coloration is confined to the dorsum, whereas in the pine mouse the reddish coloration extends onto the sides. In addition, the ears of the red-backed mouse are larger, the tail is considerably longer, and the fur is longer, coarser, and less mole-like.

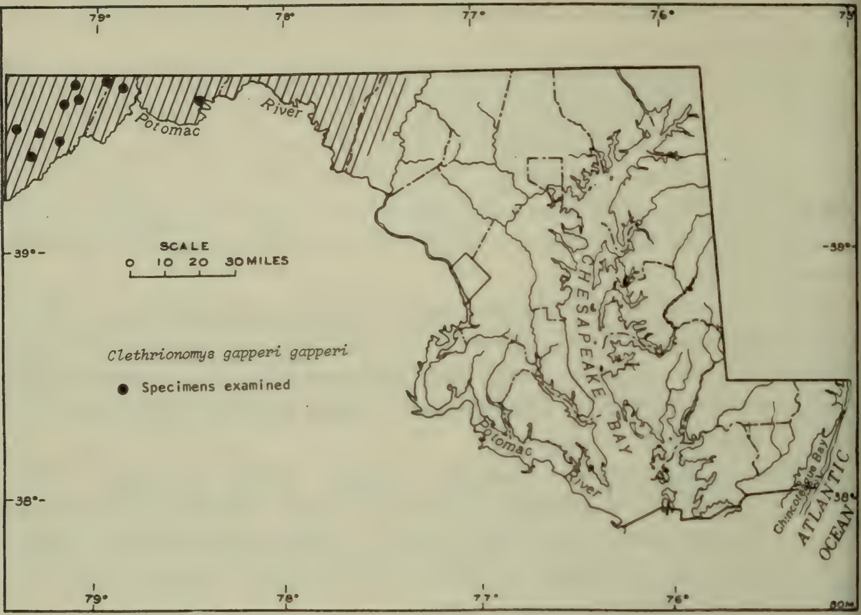

FIGURE 37.—Distribution of *Clethrionomys gapperi gapperi*.

Measurements.—Ten adults from Garrett County have the following external and cranial measurements: Total length 147.3 (140–155); tail 42.9 (38–48); hind foot 19.5 (19–20); condylobasal length of skull 24.9 (24.1–25.8); zygomatic breadth 13.3 (13.0–13.7); interorbital breadth 4.0 (3.9–4.2); length of molar toothrow 5.4 (5.2–5.6).

Habitat and habits.—This mouse prefers cool, damp, forested areas where it lives among the mossy rocks and rotten logs. In the northern part of its range it is widely distributed, but in Maryland it is restricted to the higher mountains, where it is locally abundant. Preble (field notes) took the red-backed mouse at Finzel on the border of a hemlock woods, and at Grantsville he found that it was very common in a tract of hemlocks 3 miles east of the town. It was also abundant in the mixed forest covering the steep slopes on the east side of the Castleman River, and in the hemlock woods near Bittinger. At Mountain Lake Park, Preble took a specimen among rocks in an oak woods, and at Swanton he trapped a very dark individual in deep hemlock woods. Bookhout tells me that he trapped one in Allegany County in a rock outcrop in a second-growth oak-hickory forest.

This species does not make elaborate tunnels, but will occupy those made by moles and shrews. Jackson (1961, pp. 227–228) has described a nest in detail. It was located among the rootlets of small trees and was some 3 inches in diameter. The nest was merely a small carpet of grass stems and a few particles of dead leaves and moss, the entire bulk of which would be no larger than a man's thumb. Another nest was located at a depth of about 18 inches under a rotten elm stump. It was situated on top of the soil underneath a root of the stump, and was 4 inches in diameter and about 1 inch in depth, slightly hollow and without cover other than the log above. It was composed of small pieces of dry leaves, bark, hazelnut shells, hemlock cones, twigs, dry sphagnum, and green moss.

According to Hamilton (1941, p. 259), in New York State about three-fourths of the food of this species is composed of green vegetation. In addition, a large part of the diet consists of nuts and seeds. Insects are not as often eaten as they are by white-footed mice.

The red-backed mouse does not hibernate, but it does actively gather stores in the fall in preparation for winter. The breeding season is protracted, beginning in the late winter or early spring and extending well into fall. One litter follows another during the breeding season, and from two to eight young comprise a litter. The gestation period is 17 to 19 days.

Specimens examined.—Allegany County: Mount Savage, 6 (Coll. U. Md.); Town Hill Mountain, near beacon light, 1 (Coll. U. Md.). *Garrett County:* Bittinger, 7; Cranberry Swamp, 4 (Coll. U. Md.); Finzel, 5; Grantsville, 3 miles E, 15; Mountain Lake Park, 1; Swallow Falls State Forest (near Muddy Creek Falls), 1; Swanton, 1; Thayerville Swamp, 2 (Coll. U. Md.); Wolf Swamp, 1.

Remarks.—Maryland *C. g. gapperi* average somewhat darker and slightly larger than specimens of this subspecies from Ontario and central New York. They appear to be intergrades between *C. g. gapperi* and *C. g. carolinensis* but are more closely related to the former. The specimen collected by Preble in the deep hemlock woods at Swanton is as dark and large, however, as typical *carolinensis*.

MEADOW VOLE

Microtus pennsylvanicus (Ord)

Two races of this widespread and abundant small mammal are recognizable in Maryland. They are:

Microtus pennsylvanicus pennsylvanicus (Ord)

Mus pennsylvanicus Ord, in Guthrie, a new geogr., hist., comm. grammar . . . Philadelphia, 2d Amer. ed., 2: 292, 1815.

Type locality.—Meadows below Philadelphia, Pa.

General distribution.—From Quebec and New Brunswick, south into Georgia, and west into Nebraska, South Dakota, and North Dakota.

Distribution in Maryland.—Distributed in the Piedmont, Ridge and Valley, and Allegheny Mountain sections. Intergrades with *Microtus* *p. nigrans* in the Eastern Shore and Western Shore sections, and is replaced by that subspecies in the southern Eastern Shore and southeastern Western Shore sections. (See fig. 38.)

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; molar teeth rootless and persistently growing; coloration of upperparts dull chestnut brown, darkest along the middle of the back; underparts grayish white, or buffy white; feet grayish brown; tail dusky above, paler below, fur overlaid with coarse guard hairs; tail less than a third of total length of animal.

This vole is similar in appearance to the red-backed mouse (*Clethrionomys gapperi*), but is larger and more brownish in coloration, and lacks the red dorsal band. It is also similar in appearance to the pine vole (*Pitymys pinetorum*) but has coarser pelage, bigger ears, and a longer tail. It differs from the southern bog lemming (*Synaptomys cooperi*) in its coarser, shorter pelage and much longer tail, and in lacking grooved upper incisors.

Measurements.—Eleven adults from the vicinity of Oldtown, Allegany County, have the following external and cranial measurements: Total length 169.2 (161.0–187.0); condylobasal length of skull 28.5 (28.1–29.0); zygomatic breadth 15.4 (14.8–15.9); interorbital breadth 3.6 (3.4–4.0); maxillary toothrow 6.9 (6.5–7.3). Males average somewhat larger than females.

Habitat and habits.—This vole is numerous in fields and meadows throughout the State. It is also common in marshes and similar areas with heavy growth of grass; occasionally it is found in orchards and open woodland if the ground cover is grassy. This is one of the most abundant mammals in Maryland.

Meadow voles construct extensive runways on the surface of the ground. These runways are about 1½ inches in diameter and run in a network under the cover of dead grass. They are sometimes the only sign of the presence of these voles in an area. If the runway is fresh and is being used, there will generally be droppings and cut pieces of grass at various intervals along it. The nest of the meadow vole is usually constructed on the surface of the ground in one of the runways. It is bulky, generally about 5 or 6 inches in diameter and 3 or 4 inches deep, usually covered, but sometimes not.

The meadow vole is active both day and night. It is cyclic in nature and the reproductive habits vary from year to year (Hamilton, 1937). It is polyestrous and may breed the year round, although in Maryland there is a tendency not to breed during the coldest part of winter. The females reach puberty and begin to breed at 25 days of age, and from six to eight young generally comprise a litter. The gestation period in this species is 21 days, or a little less, and as many as 17 litters may be produced in a year.

The food of the meadow vole consists chiefly of fresh grass, sedges, grains, and seeds. Green vegetation comprises the major portion of its diet in the spring and summer, while in the fall, grains and seeds are an important commodity. In winter, bark and roots of shrubs and trees are sometimes consumed.

Hamilton (1943, p. 327) says that the meadow vole is of great economic importance. By girdling fruit trees and nursery stock it causes monetary loss to the horticulturist. The amount of forage crops it consumes, while difficult to measure, is in the aggregate a very great loss to the farmer. It does, however, perform a useful function in providing predatory birds and mammals with an abundant source of food.

Specimens examined.—Allegany County: Cumberland, 2; Mount Savage, 8; Oldtown, 4 miles E, 19; Oldtown, 9 miles E, 74; Sideling Hill Creek, 3. *Anne Arundel County:* Annapolis, 1 mile W, 6; Annapolis, 3 miles W, 4; Annapolis, 4 miles W, 2; Lake Shore area, 1. *Baltimore County:* Loch Raven, 2. *Charles County:* Nanjemoy Creek, 2; Newport, 5. *Garrett County:* Finzel, 1; Grantsville, 1; Mountain Lake Park, 2. *Howard County:* Atholton, ½ mile S, 5; Long Corner, 1. *Montgomery County:* Cabin John Bridge, 1 mile N, 1; Kensington, 1; Rockville, 2.3 miles NE, 3; Seneca, 1½ miles NW, 26; Seneca, 2.9 miles W, 52; Silver Spring (vicinity), 5. *Prince Georges County:* Collingwood (=Collington?), ½ mile S, 2; Hyattsville, 10; Lanham, 1; Laurel, 30; Oxon Hill, 11; Riggs Mill, 1. *Queen Annes County:* Parson Island, 2. *District of Columbia:* 91.

Other records and reports.—Allegany County: Dans Mountain (Coll. U. Md.); La Vale (Coll. U. Md.); McCoole (Coll. Carnegie Museum). *Anne Arundel County:* Dorsey (U.S. Fish and Wildlife Service files). *Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948, p. 67); Patapsco State Park (Hampe, 1939, p. 6). *Garret County:* Cranberry Swamp (Coll. U. Md.). Cranesville Pine Swamp (Mansueti, 1958, p. 83); Cunningham Swamp (Coll. U. Md.). *Prince Georges County:* Patuxent Research Center (Herman and Warbach, 1956, p. 87).

Remarks.—This subspecies intergrades with *Microtus p. nigrans* in the Eastern Shore and Western Shore sections. Specimens from the northern portion of these sections (Parson Island, Annapolis vicinity, Laurel, Oxon Hill) are, however, clearly referable to *M. p. pennsylvanicus*, as is a small series from Newport, in the south central Western Shore section.

Microtus pennsylvanicus nigrans Rhoads

Microtus pennsylvanicus nigrans Rhoads, Proc. Acad. Nat. Sci. Phila., 49:307, 18 June 1897.

Type locality.—Currituck, Currituck County, N.C.

General distribution.—Near the coast from southeastern Maryland to northeastern North Carolina.

Distribution in Maryland.—Southern Eastern Shore section at least as far north as Cambridge, Dorchester County, and southeastern Western Shore section in Calvert and probably St. Marys Counties. This subspecies intergrades with *Microtus p. pennsylvanicus* in the central portion of the Western Shore section and in the northern part of the Eastern Shore section.

Distinguishing characteristics.—Similar to *Microtus p. pennsylvanicus* except that it is somewhat larger and has a darker coloration, almost black in some pelages.

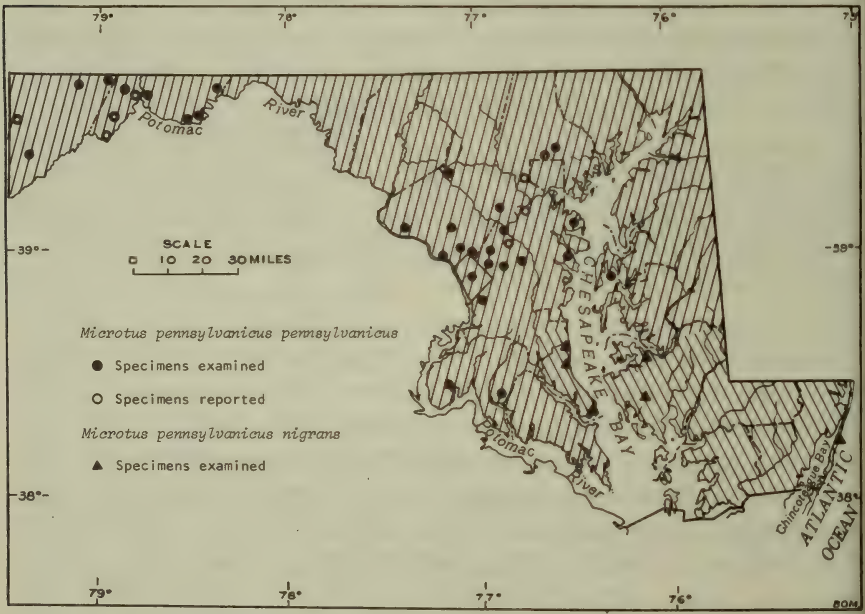

FIGURE 38.—*Distribution of Microtus pennsylvanicus pennsylvanicus* and *M. p. nigrans.*

Measurements.—External and cranial measurements of seven adults from Drum Point, Calvert County, are as follows: Total length 173.1 (168–184); tail 47.8 (42–52); hind foot 22.6 (22–23); ear 14.3 (12–16); condylobasal length of skull 29.1 (28.1–30.5); zygomatic breadth

15.9 (15.4–16.6); interorbital breadth 3.8 (3.5–4.0); maxillary toothrow 6.8 (6.6–6.9).

Habitat and habits.—In the southern Eastern Shore section, this subspecies abounds in the dryer portions of brackish and salt marshes along the Atlantic seacoast and the Chesapeake Bay. It is probably the most abundant mammal occurring on Assateague Island. As an example of its numbers on this outer barrier island, it may be noted that in a single night in the spring of 1956, 60 specimens were taken in 100 traps set in tall grass and myrtle on the edge of a fresh water impoundment on the Virginia portion of the island a few miles south of the Maryland line. It also lives in the marshes of the Blackwater National Wildlife Refuge in Dorchester County where it builds nests in muskrat houses (Harris, 1953).

In the Western Shore section, in Calvert County, this vole has been taken in dry meadows and brushy fields.

The habits of this subspecies apparently differ in no essential respect from those of *Microtus p. pennsylvanicus.*

Specimens examined.—Calvert County: Breezy Point, 1; Drum Point, 12; Scientists Cliffs Road (1 mile E Route 2), 2. *Dorchester County:* Blackwater National Wildlife Refuge, 5; Cambridge, 5. *Worcester County:* Assateague Island, 4 and 5 miles S Ocean City, 10.

PINE VOLE

Pitymys pinetorum scalopsoides (Aud. and Bachman)

Arvicola scalopsoides Audubon and Bachman, Proc. Acad. Nat. Sci. Philadelphia, 1:97, October 1841.

Type locality.—Long Island, N.Y.

General distribution.—Northeastern United States, from central New England, south to Virginia and western North Carolina, west to Illinois and Wisconsin.

Distribution in Maryland.—Common in all sections of the State.

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; molar teeth not rooted, and grow persistently; tail very short, buffy brown above, lighter below; ears very short, and hidden in fur; pelage short, soft and glossy, almost mole-like; coloration russet to chestnut brown on dorsum, becoming lighter on sides; underparts grayish buff; feet grayish brown.

This species resembles the meadow vole (*Microtus pennsylvanicus*) from which it may be distinguished by its shorter tail, shorter ears, and finer, more russet pelage. It differs from the red-backed mouse (*Clethrionomys gapperi*) in that the reddish coloration of the dorsum extends onto the sides and is not confined to a band on the dorsum; smaller ears; shorter tail; fur shorter, softer and more mole-like.

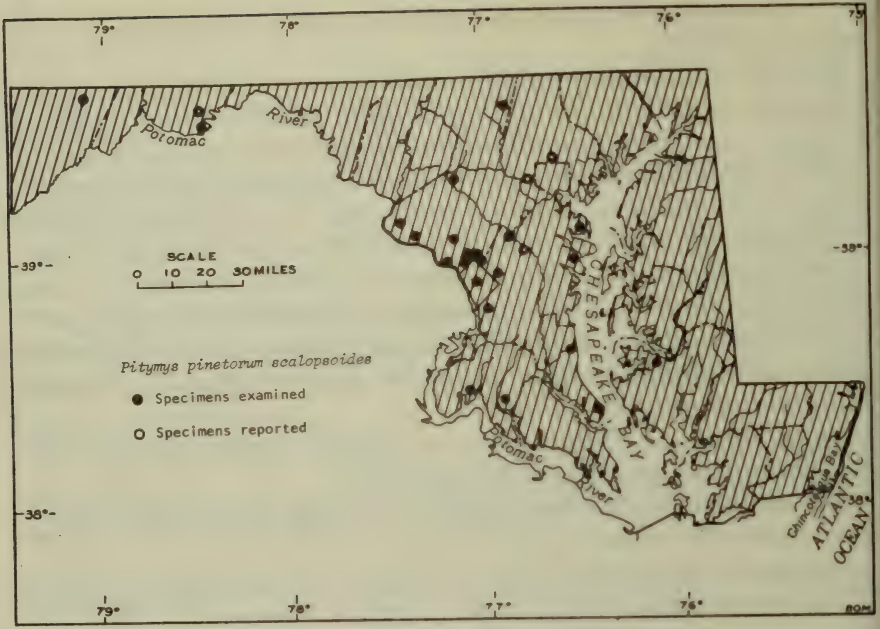

FIGURE 39.—Distribution of *Pitymys pinetorum scalopsoides.*

From the southern bog lemming (*Synaptomys cooperi*) this species may be readily distinguished by the lack of grooves on the upper incisors.

Measurements.—Ten adults from the District of Columbia have the following external measurements: Total length 124.8 (120–131); tail 22.1 (15–25); hind foot 16.6 (16–18). Eleven adults from the District of Columbia have cranial measurements as follows: Condylobasal length 24.9 (24.2–25.9); zygomatic breadth 15.5 (14.2–16.3); interorbital breadth 4.2 (3.9–4.6); length of maxillary toothrow 6.1 (5.8–6.5).

Habitat and habits.—This species is not particular with regard to habitat preference, being found in old fields, wood borders, and cultivated fields, especially in loose sandy soils. It is often found in old apple orchards where the soil is mellow and sandy, and the grass and weeds have been allowed to grow, forming a heavy protective carpet of vegetation. The fallen apples also provide the mice with food in autumn, and the bark of apple roots supply a favorite winter food. Contrary to its name, the pine vole is seldom found in pine woods in Maryland.

Hamilton (1938, pp. 163–170) in his life history study of the species says that the animal threads its way just beneath the thick carpet of leaves which forms a ceiling to its burrow. Rarely the pine vole tunnels to a depth of a foot or more, but by far the greater number of burrows are shallow, descending to a depth of only 3 or 4 inches. In orchards it tunnels its way to fallen apples, and then burrows up from underneath to feed on the fruit. These mice seldom leave their subterranean burrows.

The nest of the pine vole is globular in shape, and composed of almost any material the animal can procure, generally dead leaves and grasses. The nest may be just below the ground surface, or, occasionally under some shallow-rooted stump. Usually there are three or four exits.

This species feeds largely on roots and tubers, bulbs, and the bark of trees and shrubs. It seldom eats green vegetation, seeds, or most kinds of fruit, although it does relish apples and pears. Generally, considerable quantities of roots and tubers, which presumably are utilized as the bulk of the winter food, are stored in its burrows. Pine voles often are responsible for depredations in orchards, where they frequently girdle apple trees severely.

This species is cyclic, and according to Hamilton (1938, p. 166) its reproductive behavior undoubtedly varies from year to year as does that of *Microtus*. The breeding season is from early March to mid-November, and small litters of from two to four young are produced. The gestation period in all probability approximates the 21 days of *Microtus*.

Specimens examined.—Allegany County: Oldtown, 9 miles E, 4. *Anne Arundel County:* Annapolis, 3 miles NW, 2; Lake Shore area, 2. *Calvert County:* Plum Point, 2 miles W, 1; Solomons Island, 3½ miles N, 1. *Carroll County:* Hampstead, 1. *Charles County:* Newport, 3; Port Tobacco, 3 miles SW, 1. *Dorchester County:* Cambridge, 3. *Garrett County:* Grantsville, 1. *Howard County:* Long Corner, 1. *Montgomery County:* Chevy Chase, 1; Kensington, 2; Montgomery Knolls, 1; Plummers Island, 5; Poolesville, 1 mile NE, 1; Rockville, 2.3 miles NE, 10; Seneca, 1.3 miles W, 1; Seneca, 1½ miles NW, 1; Silver Spring, 1; Takoma Park, 1; Woodside, 5. *Prince Georges County:* Bladensburg, 1; Laurel, 9; Oxon Hill, 1. *District of Columbia:* 61.

Other records and reports.—Allegany County: Green Ridge (Coll. U. Md.). *Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948: 68); Patapsco State Park (Hampe, 1939: 7). *Prince Georges County:* Patuxent Research Center, along Patuxent River (Stickel, Lucille F., 1948: 506).

MUSKRAT

Ondatra zibethicus macrodon (Merriam)

Fiber macrodon Merriam, Proc. Biol. Soc. Washington, 11: 143, 13 May 1897.

Type locality.—Lake Drummond, Dismal Swamp, Norfolk County, Va.

General distribution.—Reported from Chester County, Pennsylvania, south in the Coastal Plain and Piedmont to the lower Cape Fear drainage of southeastern North Carolina.

Distribution in Maryland.—Eastern Shore, Western Shore, and Piedmont sections.

Muskrats are especially abundant in the fresh-water and brackish marshes of the Eastern Shore section. The subspecies *macrodon* intergrades with *O. z. zibethicus* in the Piedmont section and is probably replaced by that subspecies in the Ridge and Valley and Allegheny Mountain sections.

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; tail long and laterally compressed; hind feet partially webbed; ears small and almost hidden in fur; pelage dense, underfur soft and thick, overlaid with long smooth guard hairs; usual coloration a rich brown, with considerable bright russet to red tinge, darker on head, nose, and back; sides grayish brown to russet; underparts considerably lighter, varying from grayish drab to bright cinnamon rufous.

There is a black color phase of this subspecies which in some Maryland marshes runs as high as 65 percent of the population (Dozier, 1948*b*, p. 393). These animals are not uniformly black, but have a modified agouti pattern shown in the lighter ventral surfaces and on the lower side areas where the hairs are subapically banded with

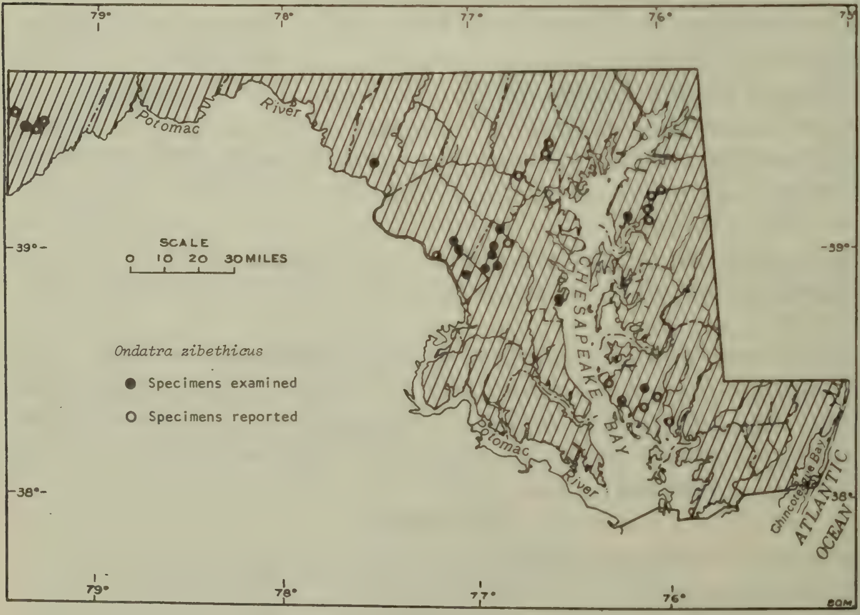

FIGURE 40.—Distribution of *Ondatra zibethicus.*

yellow. The dorsum, however, is a uniform glossy black with no hairs banded with red and yellow. Rarely an albinistic individual is encountered, and Dozier (1948*b*, p. 394) has reported upon a nonalbino white mutation ("Maryland white") occurring in some of the marshes in Dorchester County, and fawn colored mutants from the vicinity of Chestertown, Kent County.

The muskrat is readily distinguished from other Maryland rodents by the combination of its aquatic habits, large size, and laterally compressed tail. The beaver, which the muskrat resembles in aquatic habits, is larger and has a broad, horizontally compressed tail.

Measurements.—External measurements of an old male and two young adult females from Laurel, Prince Georges County, are as follows: Total length 675, 600, 570; tail 280, 275, 266; hind foot 87, 86, 79. Cranial measurements of 11 adults from Laurel are: Condylobasal length 67.6 (63.9–72.2); zygomatic breadth 41.8 (39.8–44.5); least interorbital breadth 5.9 (5.0–6.6); length of maxillary toothrow 16.1 (14.9–17.2).

Dozier et al. (1948, p. 180) found that the average weight of 13,421 male muskrats trapped on the Blackwater National Wildlife Refuge, Dorchester County, was 2 pounds 4 ounces, and the average weight of 10,090 females was 2 pounds 2 ounces. Adult males varied in weight from 6 ounces to 4 pounds, and females from 6 ounces to 3 pounds 12 ounces.

Habitat and habits.—Muskrats are most abundant in the extensive marshes that line the Chesapeake Bay. Elsewhere in Maryland they are found in streams that wind through pastures, and in swamps.

The muskrat is essentially vegetarian, but occasionally will make use of animal food such as fish, mussels, insects, crayfish, and snails. Martin et al. (1951, p. 236) report that at the Patuxent Research Center near Laurel, the most important plant material eaten is burreed, cutgrass, arrowhead, waterlily and panicgrass. Smith (1938, p. 12) found that muskrats in Dorchester County would eat, to some extent, almost any plant found in the marshes there. Certain favorities, however, form their staple diet, and no area lacking these will support a large muskrat population. Three square sedge and broadleaf and narrowleaf cattails constitute four-fifths of the animal's diet, and all parts of these plants are eaten at one time or another during the year. Other foods that are at times utilized by the muskrat in the Dorchester marshes are saltmarsh, wild reed, saltgrass, beak-rush, spikerush, big cordgrass, wild millet, and sweet sedge. Also occasionally eaten are saltmarsh fleabane, marshmallow, waterlily, dodder, iris, waxmyrtle, small pine trees, and poison-ivy. Smith found that Dorchester County muskrats sometimes consumed turtles, blue crabs, fish (chiefly sluggish kinds such as carp), salt-water mussels, and possibly dead birds.

In the Maryland marshes, muskrats are active at all hours, in the spring and throughout the summer.

Muskrat homes are of two general types depending on the topography of the area in which they live. In the uplands they dig burrows into the banks of streams and other bodies of water, while in the marshes they build dome-shaped structures. The entrance hole to a bank burrow is always below the normal level of water. The burrow turns upward above water level and ends in a nest of grass. The dome-shaped structures that they build in the marshes may be as much as 7 or 8 feet in diameter and more than 4 feet high. They are constructed of stalks, roots, and peaty remains of plants and are built on or around a firm foundation such as a stump or the base of a tree. Each house contains one or more nests from which passages lead to plunge holes in the floor. These holes in turn lead to underground tunnels that connect with the surface several feet from the house.

Muskrats are primarily aquatic and construct elaborate canals, 6 inches to a foot wide, and sometimes a foot or more deep, which are not visible when the water is high. Those canals which are used as main arteries of travel are always wider and deeper than those used only as temporary leads made in search of food. In dry areas the muskrats use surface trails concealed in the grass that lead in all directions, and except for size, resemble those made by the meadow mouse.

In addition to surface canals and trails, muskrats construct elaborate systems of underground burrows and tunnels that spread out in all directions and are connected with the surface and the canals by plunge holes scattered at convenient intervals.

Smith (1938, p. 16) found that in Maryland the muskrat may breed in any month with the possible exception of November and December. Most of the young are born from mid-April to mid-September. Most Maryland trappers report that there are three litters a year, but Smith (1938, p. 16) was only able to obtain two a year in pen-raised animals. The number of young is variable; in the Maryland investigations conducted by Smith, the number averaged 4.4, seven being the most found in any one uterus. The gestation period appears to be about 29 or 30 days, and muskrats probably first breed at the age of 1 year.

The population of muskrats in Maryland marshes apparently has been decreasing since 1939. The number of muskrats trapped in the marshes from year to year may not reflect the actual muskrat population since many factors such as food, predation, salinity, and breeding, which are not readily observable, together with the value of pelts, act together to affect muskrat abundance, and may be different from year to year. Furthermore, these factors may cause different reactions on the part of the muskrat populations at different levels of abundance. Nevertheless, trapping records probably give an adequate index of the larger fluctuations in population level in Maryland. With this in mind, Harris (1952, p. 13) lists the muskrat catch on approximately 600 acres of marsh on the Nanticoke River, Dorchester County. In 1937, the total catch of muskrat on this marsh was 2,417 animals (4.0 animals per acre). By 1950 the catch on this same marsh had dropped to 150 animals, or 0.2 animals per acre. On a Statewide level, the total catch of muskrat was estimated at 2 million in 1938. In 1949, when Maryland first began to keep accurate records of the muskrat catch, only 228,548 animals were reported trapped throughout the State. By 1957 this figure had dropped to a low of 112,348 muskrats. The 1967–68 catch was reported as 139,000.

These figures show that the muskrat population has been experiencing a decline over the past 25 years, and since the muskrat is an economically important animal, there has been considerable speculation and research devoted to the reason, or reasons, for this decline. Hardy (1950, pp. 8–9, 27) records the opinions of the trappers themselves regarding this decline, which includes such ideas as there being a definite ecological relationship between muskrats and domestic hogs. These trappers stated that with the fencing in of property in Dorchester County the hogs were no longer able to root in the marshes and, hence, the ecological relationship of the two species was destroyed and the muskrat population declined. Another theory maintained by some of the trappers is that owing to various causes there has been a great increase in the number of eels in Dorchester County waters and that eels enter the muskrat houses and consume young. Other ideas are that the muskrat decline is due to increased predation by raccoons and foxes; a "dreadful disease"; floristic changes; "trapping under" (placing the trap in underground leads); and high water. Hardy (1950, p. 27) notes that some of these factors may have been operative, but that it can safely be assumed that the diminishing population of the muskrat in Dorchester County has been brought about by a combination of ecological and environmental changes rather than by any single factor. Harris (1952, p. 36) points out that his study on Dorchester County muskrats did not answer the question why there has been a decline in their numbers, but it did show that the combination of predation and a reduced capacity of the marsh to support muskrats may prevent a rapid increase in the muskrat population.

Specimens examined.—Anne Arundel County: Broadwater, 1. *Dorchester County:* Blackwater National Wildlife Refuge, 8. *Frederick County:* Jefferson, 1. *Montgomery County:* Forest Glen, 1; Kensington, 1; Sligo Branch, 1. *Prince Georges County:* Beaverdam Creek, 1; Beltsville, 1; Branchville, 3; Lanham, 2; Laurel, 147. *District of Columbia:* 6.

Other records and reports (from Dozier, 1948*b*, unless otherwise noted).—*Baltimore County:* Bare Hills–Lake Roland area (Bures, 1948, p. 68); Loch Raven (Kirkwood, 1931, p. 317); Patapsco State Park (Hampe, 1939, p. 7). *Dorchester County:* Best Pitch Ferry; Elliotts Island; Fishing Bay; Joe's Point; Robbins, near; Taylors Island; World End Creek, near Golden Hill. *Garrett County:* Piney Run, near Piney Dam (trapping record, Maryland Nat. Res. Inst.); Pawn Run, as it enters Deep Creek (trapping record, Maryland Nat. Res. Inst.). *Kent County:* above and below Chestertown, on the Chester River; Chestertown (specimens in Acad. Nat. Sci. Phila. collection); Fairlee Creek near its Chesapeake Bay Mouth. *Montgomery County:* Mainland across from Plummers Island (Goldman and Jackson, 1939, p. 133). *Prince Georges County:* Patuxent Research Refuge (Uhler & Llewellyn, 1952, p. 81). *Queen Annes County:* Booker's Wharf.

Remarks.—I have not been able to examine specimens from the Ridge and Valley and the Allegheny Mountain sections, but one specimen I examined from Jefferson, Frederick County, just to the east of the Blue Ridge Mountains, is clearly an intergrade with *Ondatra z. zibethicus* in size and coloration, and almost near enough to typical *zibethicus* to be assigned to that subspecies. On the basis of this specimen, and because of the known distribution of *O. z. zibethicus* in Virginia and Pennsylvania, the muskrats of the Ridge and Valley and Allegheny Mountain sections probably are referable to the subspecies *zibethicus*. This subspecies appears to intergrade with the Coastal Plain subspecies *macrodon* throughout most of the upper Piedmont section.

Published reports of this species in western Maryland are by Browning (1928, p. 213) who saw muskrats around 1825 in the vicinity of Deep Creek Lake in Garrett County, and by Mansueti, (1958, p. 83), who observed them in Cranesville Swamp, Garret County, in the 1950's. The species is present in suitable streams and ponds throughout the Ridge and Valley and Allegheny Mountain sections at the present time, and according to Flyger (in verbis, 22 June 1964) trappers report that they are not uncommon.

Ondatra z. zibethicus differs from *O. z. macrodon* in its darker pelage (in normal color phase), and in its smaller size. It is of interest to note that Merriam in his original description of *macrodon* (specimens from Dismal Swamp, Virginia) considered the subspecies to be a much darker form than *zibethicus*. Merriam's specimens, however, were mostly dark phase animals, and as Hollister (1911, p. 18) has shown, *macrodon* (in normal color phase) is actually a lighter and brighter colored subspecies than *zibethicus*.

SOUTHERN BOG LEMMING

Synaptomys cooperi stonei Rhoads

Synaptomys stonei Rhoads, Amer. Nat., 27: 53, January 1893.

Type locality.—May's Landing, Atlantic County, N.J.

General distribution.—Southern Appalachians of eastern Kentucky and Tennessee, western North Carolina and Virginia and western Maryland to the Atlantic Coastal Plain of Maryland, Delaware, and New Jersey, and northward to Connecticut and coastal Massachusetts.

Distribution in Maryland.—Statewide in distribution. The most southeasterly record for the subspecies *stonei* is in Worcester County (Poole, 1943, p. 103).

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; size medium; tail short; fur rather long and shaggy; head broad; ears short, rising slightly above the fur; upper incisor teeth grooved. Coloration of upper parts brown to chestnut, grizzled in appearance; underparts silvery, with no sharp line of demarcation on the sides; tail grayish black, not sharply bicolored; feet brownish black.

This is the only short-tailed mouse in Maryland which has grooved upper incisors, and may thus be distinguished from all others. Cranially, the southern bog lemming has a shorter rostrum than any other Maryland mouse.

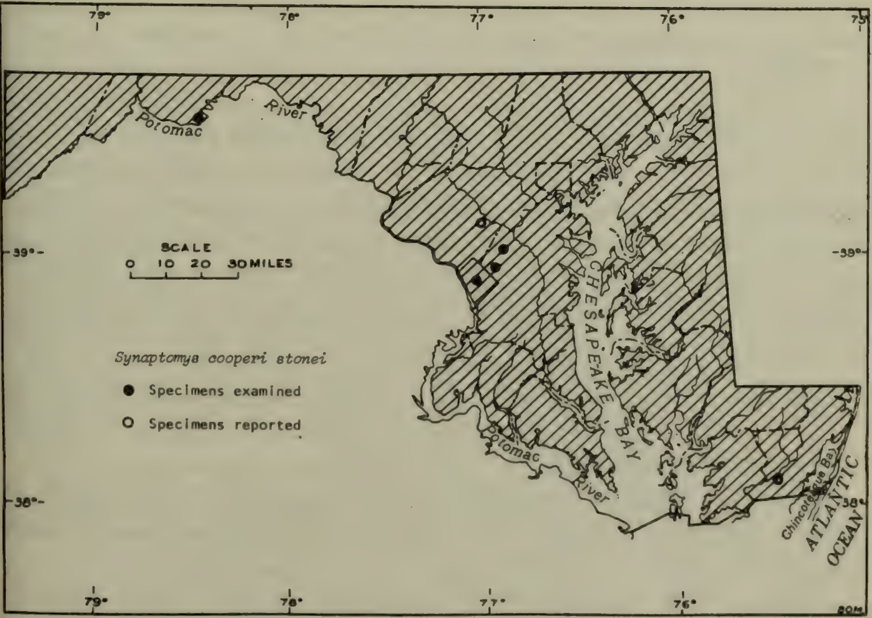

FIGURE 41.—Distribution of *Synaptomys cooperi stonei*.

Measurements.—External measurements of five adults, and cranial measurements of six adults from Laurel, Prince Georges County, are as follows: Total length 127.4 (120–135); tail 21.2 (18–23); hind foot 19 (18–20); greatest length of skull 24.7 (24.3–24.9); zygomatic breadth 17.0 (16.5–17.5); interorbital constriction 2.9 (2.7–3.1); length of maxillary toothrow 7.5 (7.4–7.8).

Habitat and habits.—This species has a preference for sphagnum bogs, and this is where most Maryland specimens have been collected. It is sometimes found, however, in woodland habitats, including beach-maple, oak-hickory, and pine. Specimens have even been taken in grassy areas, orchards, weedy fields, and marshes, and in shocked corn.

According to Conner (1959, p. 171) the chief requirement of *Synaptomys* seems to be the presence of green succulent monocotyledonous plants, primarily sedges and grasses, which are its main source of food.

This species may breed throughout the year, although Conner (p. 203) found that in southern New Jersey there was a spring peak in the breeding cycle, with some breeding continuing through summer and autumn. Poole (1943, p. 103) found a lactating female in Worcester County, Md., in late November. Conner (p. 202) found that litters of from two to five were usual for the species, although a single embryo is not uncommon, and as many as seven young have been reported. His data suggest that in the spring and summer females produce a litter every 67 days.

Wherever the southern bog lemming occurs, it is found in company with other small mammals such as red-backed mice, deer mice, shrews, and moles, and it often occupies the same burrows as these others. The nests are constructed of shredded grasses and sedges and are often concealed some distance beneath the ground. Less often, they are placed directly on the ground where there is sufficient ground cover. Conner (p. 227) found that most of the nests in southern New Jersey were located just under the surface, concealed in either hemlock or moss or in other elevated mounds in the bogs. Most of the nests were balls of dry shredded leaves of sedge, and had two entrances. The diameters ranged from 3½ to 6 inches, and the hollow spaces within the nests averaged about 2½ inches.

Specimens examined.—*Allegany County:* Oldtown, 9 miles E, 1. *Prince Georges County:* Beltsville, 1; Beltsville, 2½ miles W (sphagnum bog), 5; Hyattsville, 8. *District of Columbia:* 1.

Other records and reports.—*Montgomery County:* Sandy Springs [skull removed from stomach of red-tailed hawk] (Bailey, 1923, p. 118). *Worcester County:* Snow Hill, 6 miles SW (Poole, 1943, p. 103).

Remarks.—The specimen from 9 miles E of Oldtown, Allegany County, is somewhat smaller in size and less grizzled in coloration than those from farther east in the State. This animal may represent an intergrade in these characters with *S. c. cooperi*, the subspecies distributed to the north of *stonei*, or may actually be referable to that form. As Wetzel (1955, p. 12) has pointed out, however, the ranges of all measurements in these two subspecies overlap, and the variation in coloration within only one sample of *cooperi* for one season is much greater than between the various subspecies of *S. cooperi.* This illustrates the difficulty in assigning individual specimens to subspecies. Because of this, the specimen from Allegany County is provisionally assigned to *S. c. stonei*, the range of which is herein considered to encompass the entire State. When more specimens from the Piedmont and the Ridge and Valley sections become available for study, however, it may be found that *S. c. cooperi* is distributed in those sections, and that the specimen from Allegany County should properly be assigned to that race.

Family CAPROMYIDAE (hutias and coypus)

NUTRIA

Myocastor coypus (Molina)

Mus coypus Molina, Sagg. Stor. Natur. Chili, p. 287, 1782.

Type locality.—Rivers of Chile.

General distribution.—Ranges widely over southern South America; introduced into the United States in the 1930's, and now is established in the wild in at least 16 states.

Distribution in Maryland.—A few nutria are established in the Dorchester County marshes.

Distinguishing characteristics.—Teeth 1/1, 0/0, 1/1, 3/3, = 20; size large (sometimes attaining a weight of 21 lbs.); pelage consisting of 2 types of hair, dense underfur, and long glossy overlying guard hairs; coloration rich brown or chestnut on dorsum, paler underneath; tail long and cylindrical; middle toes of hind feet connected by a basal web.

This species superficially resembles the muskrat, from which it may be readily distinguished by its larger size, cylindrical as opposed to laterally compressed tail, and greater number of teeth.

Measurements.—An adult male and female from the Blackwater National Wildlife Refuge, Dorchester County, measure externally as follows: Body length 571, 518; tail 413, ——; hind foot 156, 137. Dozier (in correspondence) reports that the heaviest animal he examined at the Fur Animal Experiment Station in Cambridge, Md., weighed 21 pounds.

No skulls of this species are available from Maryland for measurement.

Habitat and habits.—The habitat of the nutria in its South American home is in marshes, swamps, and along the margins of rivers and lakes in fresh-water plant associations. Bednarik (1958, p. 2) says, however, that Randall Rhodes, Curator of Collections at the Cleveland Museum of Natural History, has told him (in personal communication 1954) that in South America he observed that nutria were mostly associated with marine waters. The temperature of the water seems to be of little importance to them, and in the United States they are now found as far north as Michigan and Washington State, where they prosper in the same type of habitat as the muskrat.

The nutria is a vegetarian, consuming a variety of aquatic plants, rushes, reeds, grasses, seeds, cattails, and sedges. In captivity it shows a marked preference for alfalfa and clover and is fond of practically all root crops except Irish potatoes. Because of its voracious appetite it has posed a serious threat to waterfowl marshes in some areas where it has been introduced.

Nutria living in streams or ponds which have steep banks burrow into them close to the water level. Each pair makes its own burrow, which is dug in and upward until well above the water level. The den is lined with grasses, and as the family grows, the burrow is enlarged.

If the nutria are living in a marsh which does not have steep banks, floating nests of aquatic vegetation are built, which resemble those made by the muskrat. Where conditions permit, part of a colony may live in floating nests in the marsh, while other animals will build bank burrows.

The gestation period of this species in Maryland is between 130 and 134 days (Dozier, unpublished data, U.S. Fish and Wildlife Service). The young seem to be born during all seasons, and there are probably two or three litters a year per female. In Louisiana, litter size averages 4.4 young (Harris, 1956).

Nutria apparently became established in the Dorchester County marshes of Maryland sometime in the early 1940's. There are no records of their occurrence there earlier, and Herbert L. Dozier, formerly Director of the U.S. Fur Animal Field Station at the Blackwater National Wildlife Refuge, does not mention their presence in the Maryland marshes in his extensive nutria correspondence in the files of the Fish and Wildlife Service dating back to the period 13 March 1939, to 3 June 1941. It is possible that Maryland's nutria population may have originated as escapees from the U.S. Fur Animal Field Station, although there is no certain proof of this. In the late 1930's and early 1940's Dozier was conducting experiments at the Blackwater Refuge on the feeding, care, and breeding of captive nutria. In one of his letters dated 18 November 1940, now in the files of the U.S. Fish and Wildlife Service, he says:

> We have recently completed two new large 100 sq. ft. inclosures in marsh and pond edge and have released a pair of nutria in each to study their reactions to various types of local habitat, etc.

There is no record of what became of the inclosures or animals, and Dozier never published, to my knowledge, the results of his study.

Maryland kept no accurate records of its annual fur catch until 1949. Prior to that, only rough estimates were made each year as to the number of animals trapped in the State, and no mention was ever made of nutria. In 1949, when trappers were first required to report their catches, four nutria were among the animals taken. No further nutria were reported until 1956, when two were trapped in the Dorchester marshes. The following year the catch was 45 and in 1958 the number had risen to 52. Since then the number reported has declined. Thirty-four were reported for 1959, none for 1960, and five in 1961. It appears that nutria in the Maryland marshes are only precariously established.

Specimens examined.—Dorchester County: Blackwater National Wildlife Refuge, 8.

Family MURIDAE (Old World rats and mice)

BLACK RAT

Rattus rattus (Linnaeus)

[*Mus*] *rattus* Linnaeus, Syst. nat., ed. 10, 1: 61, 1758.

Type locality.—Uppsala, Sweden.

General distribution.—This is an introduced species. In the United States, it is well established and abundant in the south Atlantic and Gulf Coast ports. In the northeastern United States it is found in buildings along the docks of some seaports, and at several isolated inland localities.

Distribution in Maryland.—May occur at present in some buildings along the docks in Baltimore City.

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; size medium; general build slender; muzzle sharp; ears large, almost naked, reaching or covering the eyes when laid forward; tail slender and long, at least as long as the combined length of the head and body, and sometimes longer; pelage soft, but covered with coarse guard hairs, giving it a harsh appearance.

There are three color phases of this species. Some authorities have considered these as distinct subspecies because of their general association with distinct geographic areas. One of these color phases, known as *R. r. frugivorous*, has a yellowish or reddish brown dorsum, with a white or yellowish abdomen, and is most commonly encountered in the Mediterranean area. Another color variation, *R. r. alexandrinus*, has a brownish dorsum, similar to that of *frugivorous*, but with a gray venter, and is most abundant in the Middle East and North Africa. The third color phase, known as *R. r. rattus*, has a black dorsum, with a dark gray venter, as in *alexandrinus*, and is mostly associated with the cold temperate countries of northern Europe. In general, *R. r. frugivorous* is a wild-living animal, whereas *alexandrinus* and *rattus* are nearly always associated with man and his habitations. None of these varieties, however, is exclusively limited to any of the geographic or habitational areas mentioned above, and all three forms may occur at any one locality or in any one habitat. Because of this it seems advisable at present to consider them as color phases rather than as distinct subspecies (Caslick, 1956, pp. 255–257). All of the color phases may be encountered in the United States.

Rattus rattus is most easily confused with the Norway rat (*Rattus norvegicus*). It may be distinguished from that species by its smaller size, more slender build, more elongated nose, larger longer ears, and much longer and more slender tail (as long as, or longer than, the combined length of the head and body). Cranially, the two species differ in that the braincase of *R. rattus* is shortened and rounded, whereas that of *R. norvegicus* is narrow and elongated, the well-developed temporal ridges extending parallel to each other for a considerable distance on each side of the cranium.

Measurements.—Two adults from Washington, D.C. (taken on a river boat at the Seventh Street Wharf on 23 April 1923) measure as follows: Total length 405, 423; tail 218, 238; hind foot 37, 39; greatest length of skull 43.6, 43.2; zygomatic breadth 20.8, 20.9; interorbital constriction 6.4, 6.7; length of maxillary toothrow 7.0, 6.9.

Habitat and habits.—This rat is essentially an arboreal animal and seldom inhabits burrows. Where it infests buildings and houses, it is found usually in the walls, ceilings, or roof, but seldom in basements or in sewers. It shuns water and seldom enters it voluntarily. This is, however, the common rat on ships, to which it gains access by climbing the moorings. It is occasionally introduced with shipments of grain or fruit.

In diet, the black rat is omnivorous, consuming a wide variety of grains, fruits, vegetables, and animal matter.

The species is polyestrous all the year round. The duration of gestation is about 21 days, and the average litter size is seven to nine.

Black rats enter into close relations with man wherever they occur, and for this reason they are often involved in the transmission of diseases, principally the bubonic plague.

Specimens examined.—District of Columbia: Five (three taken on river boat at Seventh Street Wharf, and two taken in the Central Market in a box of fruit from Egypt in February 1912).

Remarks.—It is generally believed that the black rat was the common rat of the eastern United States before the late 18th century. Around that time, it is said, the Norway rat was introduced, and because it is a larger and more aggressive animal it drove the black rat out except near shipping ports (see Bailey, 1923, p. 114). There is however, no real evidence that the black rat was ever well established in Maryland or in any other Northeastern State. This animal prefers a warm climate and probably found Maryland too cold for its liking. Moreover, it is known that in areas in the South the black rat and the Norway rat live in the same habitations without one species driving away the other. In areas where the two species live together, however, there seems to be an ecological separation in that the black rat usually is found in the upper stories of a building, while the Norway rat inhabits the basement and adjacent sewers and tunnels.

At the present time there are no known colonies of this species in Maryland, although perhaps a few animals inhabit some of the building along the docks in Baltimore City. In 1949 Davis and Fales (1949, p. 248) reported them present in only three Baltimore buildings and estimated the population as not more than 1,000. This rat, however, is the common ship variety and probably has been, and will continue to be, repeatedly introduced into the Baltimore wharf district.

As far as is known, none are established now in Washington, D.C., although here again they may leave boats and take up residence in nearby buildings. Five specimens have been taken in the District of Columbia. Three of these were removed from a boat that had docked at the Seventh Street Wharf in April 1923, and two were trapped in January and February of 1912 at the old Central Market, to which they apparently had been brought in baskets of fruit from Egypt.

NORWAY RAT

Rattus norvegicus (Berkenhout)

Mus norvegicus Berkenhout, Outlines of the natural history of Great Britain and Ireland, 1:5, 1769.

Type locality.—England.

General Distribution.—This is an introduced form that has become widely established throughout North America.

Distribution in Maryland.—Statewide.

Distinguishing characteristics.—Similar to *R. rattus*, but differs in being larger, heavier, and shorter tailed. In coloration it is grayish or reddish brown on the back, heavily lined with black hairs along the middorsal line. The belly is silvery gray, but in some specimens it may be washed with a dingy yellowish - brown. Cranial differences between this species and *Rattus rattus* are described under the latter species.

Young Norway rats superficially resemble the native American rice rats (*Oryzomys palustris*). They may always be distinguished from this species, and from other cricetines, by the upper molar teeth, which in the genus *Rattus* (and in the other introduced Murid genus *Mus*) are provided with small rounded cusps (tubercles) arranged in three longitudinal rows in contrast to two rows of longitudinal cusps in most cricetines.

Measurements.—An adult from the District of Columbia measures as follows: Total length 470; tail 208; hind foot 43; ear 21; greatest length of skull 52.6; zygomatic breadth 27.6; interorbital breadth 7.4; length of maxillary toothrow 7.3.

Habitat and habits.—This is essentially a water-loving and burrowing animal. In the spring of 1963, large numbers of them were inhabiting burrows in the banks bordering the Loch Raven Reservoir north of Baltimore. They would emerge from the burrows in broad daylight, dive into the reservoir, and swim considerable distances to obtain scraps of bread thrown into the water by visitors who were feeding the numerous carp which swim in the area near the dam. In Washington, D.C., the population of Norway rats has recently risen to alarming proportions. Their burrows may be seen around many of the downtown government buildings and monuments, and at dusk they come into the open and actively forage for food among the refuse and rubble left by tourists during the day.

The city of Baltimore has always had a Norway rat problem, but these animals are not as numerous as was thought at one time. In a careful study of Baltimore's rat population in 1949, Davis and Fales (1950, p. 146) estimated there were approximately 43,000 animals, with a range of from 26,000 to 68,000, of which about 15,000 were in commercial areas. They had estimated that the population in 1947 was 165,000, so that there was a considerable decline in the period 1947 to 1949. With improved sanitation and methods of extermination developed during the intervening years it may be assumed that the rat population of the city at present is no higher, and probably lower, than in 1949. Nevertheless, rats are still a serious economic and public health problem in Washington and Baltimore.

The Norway rat is known to occur throughout the State both in commercial buildings and habitations, and in some places in the wild, particularly in the summer.

The species is extremely adaptable, and about the only factor essential for its success is the presence of water; it drinks freely, and is a good swimmer and diver. It will eat virtually anything, and finds sewers particularly attractive places to live because of the abundant water supply and the offal usually found therein upon which it can feed. From the sewers it will readily pass into buildings where it may cause considerable damage.

The species is an efficient burrower, and out-of-doors its bank burrows consist of winding galleries furnished with several escape holes. On farms, it frequently makes burrows in manure piles, rubbish mounds, wheat stacks, and hay ricks. Many Norway rats spend the summer months in fields and meadows, and at the approach of cold weather migrate into towns and villages where they seek the warmth of commercial buildings and other habitations.

The gestation period in the Norway rat is 21 days. Studies in England (Hinton, 1931, p. 13) indicate that the average number of young per litter is eight or nine, but that there are records of as many as 23. Usually the number ranges between 6 and 19, and the females may produce five or six litters annually.

It is generally believed that the Norway rat and the black rat are incompatible, and that the larger, more aggressive Norway rat will drive out or kill the smaller, weaker black species wherever they are occupying the same area. There is no proof of this, however, and there are even cases known where the two species have lived together in the confines of a small ship (John Jones, U.S. Fish and Wildlife Service, in verbis). The fact that they only infrequently occur together is probably the result of their preference for different climatic situations. The Norway rat is essentially a northern, cool climate animal and prospers in the temperate regions of northern Europe and North America. The black rat originated in warm, semitropical areas and find its optimum conditions in the warm Mediterranean regions and in the southern portions of the United States. It seems probable that the black rat, although repeatedly introduced, has never been firmly established in the northeastern United States and that the Norway rat has been the common house rat in Maryland since early colonial times.

Speciments examined.—Anne Arundel County: Fort Meade, 1. *Baltimore City:* 1. *Calvert County:* Solomons Island, 1. *Montgomery County:* Silver Spring, 1 mile N, 3. *District of Columbia:* 77.

HOUSE MOUSE

Mus musculus Linnaeus

Mus musculus Linnaeus, Syst. nat., ed. 10, Vol. 1, p. 62, 1758.

Type locality.—Uppsala, Sweden.

General distribution.—This is an old world species that has been introduced into the United States and is now found in a commensal and feral state throughout the country.

Distribution in Maryland.—Occurs abundantly as a commensal or as a feral animal in all sections of the State.

Distinguishing characteristics.—This small mouse is well known and needs no extensive description. The upper molar teeth of the house mouse are essentially like those in *Rattus rattus* and R. *norvegicus*, that is, with three rows of longitudinally arranged cusps. This distinguishes the species from all other Maryland mice of small size.

Externally, the house mouse superficially resembles American mice of the genera *Peromyscus* and *Reithrodontomys*. It differs from Maryland *Peromyscus* externally in its smaller size and in coloration. In adult pelage, *Peromyscus* is generally a brownish gray in coloration on the dorsum, with a white venter, the line of demarcation between the two being sharply marked. The tail also is distinctly bicolored, darker above, pale below. In the house mouse, the coloration is more grayish and the abdomen is generally paler than the dorsum, but there is no sharp line of demarcation between the two, the abdomen seldom being pure white as in *Peromyscus*. In addition, the tail of the house mouse is not distinctly bicolored.

The dorsum of the juvenile *Peromyscus* is colored a uniform slaty gray, which is totally unlike the grizzled gray of the house mouse, and the venter is a snowy white as in adults, with a sharp line of demarcation between the two.

Externally, the house mouse is very smiliar in appearance to the harvest mouse (*Reithrodontomys humulis*). The most certain way of separating the two species is through an examination of the upper incisor teeth. In *Reithrodontomys* there is a longitudinal groove which runs the length of each incisor, while in the house mouse these teeth are smooth. In addition, the biting edges of the upper incisor teeth of the house mouse usually are notched, and the tips of the lower incisors fit into the notches when the jaws are closed.

Measurements.—Seven adults from the vicinity of Ocean City, Worcester County, have the following external measurements: Total length 149.3 (140–167); tail vertebrae 73 (58–88); hind foot 17.4 (16–18). Cranial measurements of five adults from the vicinity of Ocean City are: Greatest length 20.9 (19.8–21.8); zygomatic breadth 11.0 (10.6–11.5); interorbital breadth 3.4 (3.3–3.6); length of maxillary toothrow 3.2 (3.1–3.4).

Habitat and habits.—This is a very plastic animal, and it has adapted itself to a wide variety of habitats. Like the black rat and the Norway rat, it is most often encountered in or near human habitations, but is also found in the wild throughout Maryland.

This species probably is of Asiatic origin. It is efficient at climbing, jumping, and swimming; and it will eat and thrive on practically any food that man consumes. Its nest is made of soft materials and is placed in any convenient location, such as in walls, under floors and steps, in bookcases or furniture, and, in the wild, under logs or stones and other convenient recesses.

The house mouse is very prolific. It attains sexual maturity at the age of 3 months and the breeding season is of long duration. The gestation period is from 19 to 21 days, and the number of young per litter is usually five or six. The young are born blind and naked, but they mature rapidly and are able to leave the mother in about 3 weeks.

When these mice inhabit houses in large numbers, they do considerable damage by eating large quantities of food, or tainting it with their droppings. They will consume linen clothing of all types, gnaw on books, and chew holes in the woodwork. In shops, warehouses, graineries, and on farms, they are usually abundant and destructive.

In Maryland, the house mouse is found everywhere, even on marshes and dunes of the Atlantic outer barrier beaches.

Specimens examined.—Allegany County: Green Ridge, 1; Mount Savage, 7. *Anne Arundel County:* Annapolis, 3 miles NW, 1. *Calvert County:* Drum Point, 1; Plum Point, 2; Plum Point, 2 miles W, 6; Scientists Cliffs, 2; Solomons Island, ¾ mile N, 11. *Charles County:* Nanjemoy Creek, 1; Port Tobacco, 4. *Howard County:* Long Corner, 2. *Montgomery County:* Cabin John Bridge, 2; Chevy Chase, 3; Forest Glen, 5; Gaithersburg, 5 miles NE, 1; Kensington, 7; Seneca Creek, 1; Silver Spring, 1 mile N, 2. *Prince Georges County:* Beltsville, near, 1; College Park, 1; Lanham, 1; Laurel, 5; Mitchellville, 1 mile W, 9; Oxon Hill, 6; River View, 1; sphagnum bog, near District line, 1. *Queen Annes County:* Parson Island, 1. *Washington County:* Fort Frederick State Park, 2. *Worcester County:* Ocean City, 3; Ocean City, 5 miles S, on Assateague Island, 3; West Ocean City, 4. *District of Columbia:* 83.

Remarks.—Schwarz and Schwarz (1943, pp. 59–72) reviewed the species and suggest that all house mice in the United States are referable to two commensal subspecies *M. m. brevirostris* and *M. m. domesticus*, the latter being the one that supposedly occurs in Maryland. In all probability, however, house mice have been introduced into Maryland from many different areas and at many different times. The range of variation in size, tail length, and coloration in Maryland specimens is so great that I am unable to assign them a subspecific name.

Family ZAPODIDAE (jumping mice)

MEADOW JUMPING MOUSE

Zapus hudsonius americanus (Barton)

Dipus americanus Barton, Trans. Amer. Philos. Soc., 4: 115, 1799.

Type locality.—Schuylkill River, a few miles from Philadelphia, Pa.

General distribution.—Southeastern United States, east of central Indiana, and south of central New York, southward into northern Georgia.

Distribution in Maryland.—Occurs in all sections of the State.

Distinguishing characteristics.—Teeth 1/1, 0/0, 1/0, 3/3, = 18; upper incisors grooved; tail very long, blackish above, white below (not white tipped); hind legs greatly elongated; pelage short and coarse; coloration yellowish orange, suffused with blackish, the blackish particularly concentrated in the middorsal area and generally forming a rather broad band from nose to tail; coloration of underparts white, sometimes suffused with yellowish orange.

This mouse is readily distinguished from all other Maryland mice, except the woodland jumping mouse (*Napaeozapus insignis*), by its very long tail and powerful elongated hind legs. It is distinguishable from *Napaeozapus* by the presence of a premolar in the upper jaw, the absence of a white tail tip, and the more yellowish coloration (as opposed to orange in *Napaeozapus*) on the flanks.

Measurements.—Measurements of three adults from the vicinity of Seneca, Montgomery County, are as follows: Total length 195, 194, 194; tail 120, 110, 110; hind foot 26, 28, 28; ear 11, 10, 10; greatest length of skull 21.6, 22.0, 22.7; zygomatic breadth 10.5, 10.9, 10.6; interorbital breadth 4.2, 3.9, 4.0; length of maxillary toothrow 3.6, 3.7, 3.5.

Habitat and habits.—Krutzsch (1954, pp. 349–472) revised this genus, and gathered together its natural history data. Most of the following is based on his account.

The meadow jumping mouse inhabits thick vegetation, usually grasses or forbs, or both, in areas near running water. It is found both in woodland and farmland, but is most abundant in open moist areas. In Maryland, the species occurs throughout the State in suitable habitat, although nowhere does it seem particularly abundant, except perhaps on Assateague Island, where it is common in the mixed cordgrass and myrtle back of the ocean dunes.

The species is cyclical in abundance, being more numerous in some years than in others. It is ordinarily a nocturnal animal, appearing in the early dusk and remaining active until predawn. Occasionally, individuals will be active during daylight hours. Meadow jumping mice hibernate in the winter. It appears that it is necessary for this

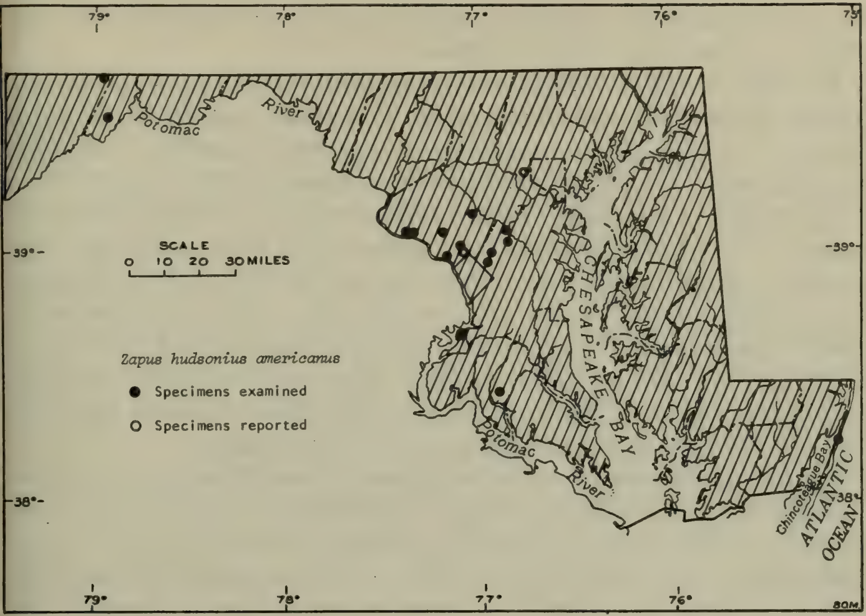

FIGURE 42.—Distribution of *Zapus hudsonius americanus.*

mouse to accumulate a certain amount of fat before it is capable of hibernation (Hamilton 1935, p. 193), and thus those taken in autumn are usually fat.

Almost invariably, meadow jumping mice hibernate in burrows in which nests are constructed of grass, leaves, or other vegetation. Grizzel (1949, pp. 74–75) found two of these animals hibernating in woodchuck dens at the Patuxent Research Center in January 1948. One animal was found 4 feet from the entrance to the burrow and about 40 inches below the surface of the ground. The second was found in another burrow 5 feet from the entrance and 26 inches below the surface. Both animals were curled up in the center of large leaf nests and well insulated from the cold.

In the vicinity of Washington, D.C., these mice remain active well into November, and emerge from hibernation in early April. In the Allegheny Mountain section, and the Ridge and Valley section, the hibernation period is more prolonged. Occasionally, during mild spells in midwinter they merge from their burrows and become active. Barbehenn tells me that he collected one jumping mouse in an old orchard with honeysuckle and poison-ivy ground cover near Rockville, Montgomery County, on 11 February 1960, in very mild weather.

During their active part of the year, meadow jumping mice wander freely and seldom make well-defined trails or runways. They construct nests of grass and leaves under logs or occasionally in a clump of shrubs a few inches above the ground.

Krutzsch (1954, p. 428), citing various investigators, lists the following foods consumed by these mice: Insects, berries, seeds, nuts, fruits of various kinds, and roots. It has been noted that meadow jumping mice are highly insectivorous (Quimby, 1951, pp. 85–86).

According to Krutzsch (1954, p. 429), meadow jumping mice commence to breed shortly after they come out of hibernation, and the breeding season is prolonged until just before they reenter hibernation in the autumn. There are probably two litters produced each breeding season, and the number of young per litter varies from three to eight. Bailey (1923, p. 120) reported a specimen from Sandy Springs, Montgomery County, taken on 19 May 1906, that contained six large embryos. The gestation period is approximately 18 days.

Specimens examined.—Allegany County: Dans Mountain, 1. *Charles County:* Marshall Hall, 1; Newport, 2. *Garrett County:* Cunningham Swamp, 4; Finzel, 1. *Montgomery County:* Cabin John Bridge, 2; Kensington, 1; Rockville, 2 miles W, 1; Sandy Springs, 2; Seneca ⅛ mile N, 1; Seneca, 3 miles W, 2. *Prince Georges County:* Branchville, 1; Laurel, 8; Patuxent Research Center, 2; Tuxedo, 1. *Worcester County:* Ocean City, 5 miles S (Assateague Island), 1. *District of Columbia:* 7.

Other records and reports.—Baltimore County: Patapsco State Park (Hampe, 1939, p. 7). *Montgomery County:* Forest Glen (one seen by G. S. Miller and reported by Bailey, 1896, p. 98). *Prince Georges County:* College Park (Krutzsch, 1954, p. 439).

Remarks.—According to Krutzsch (1954, p. 439), specimens from Maryland, Virginia, and North Carolina are more nearly average representatives of the subspecies *americanus* than are those from the region of the type locality.

WOODLAND JUMPING MOUSE

Napaeozapus insignis insignis (Miller)

Zapus insignis Miller, Amer. Nat., 25: 742, August 1891.

Type locality.—Restigouch River, New Brunswick, Canada.

General distribution.—Eastern Canada, from Nova Scotia, New Brunswick, and Quebec south of St. Lawrence River, south into northeastern Ohio, northern West Virginia, and western Maryland.

Distribution in Maryland.—Allegheny Mountain section; may also occur in the Ridge and Valley section, but has not been reported from there as yet.

Distinguishing characteristics.—Teeth 1/1, 0/0, 0/0, 3/3, = 16; closely resembles the preceding species, but somewhat larger in size; coloration

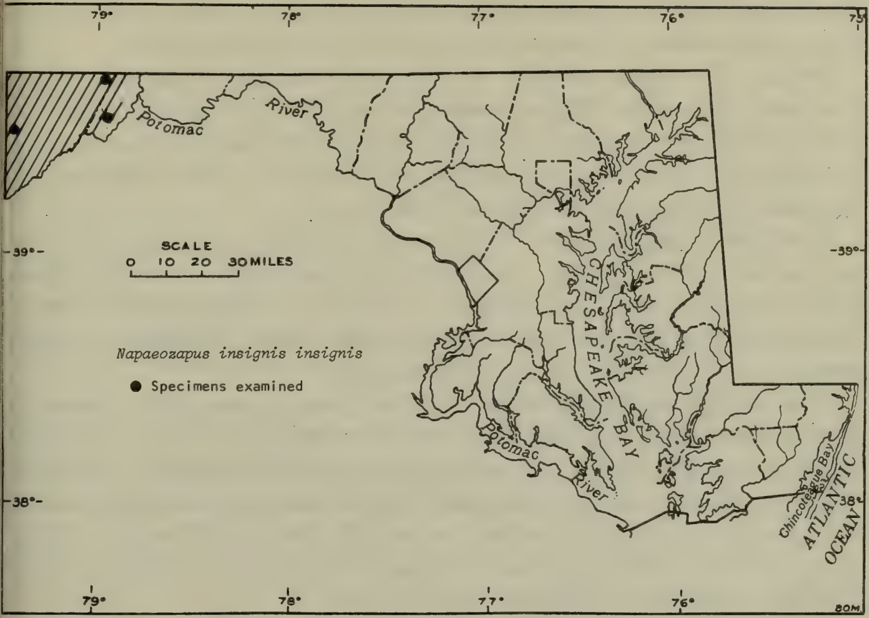

FIGURE 43.—Distribution of *Napaeozapus insignis insignis.*

similar to that of *Zapus,* but with a more brilliant orange on flanks tail grayish above, white below, with a distinct whitish tip; upper incisors grooved as in *Zapus;* only 3 molars present in maxillary, as opposed to 3 molar and 1 premolar in *Zapus.*

Measurements.—Measurements of six adults (Coll. U. Mich.) from 5 miles SE of Grantsville (alt. 2,500 ft.), Savage River State Forest, Garrett County, are as follows: Total length 223 (215–230); tail 134.7 (130–138); hind foot 30 (29–31); ear 16.2 (16–17); greatest length of skull 23.1 (22.2–23.7); zygomatic breadth 12.1 (11.8–12.3); interorbital breadth 4.5 (4.1–4.7); length of maxillary toothrow 3.6 (3.4–3.8).

Habitat and habits.—This species prefers the moist, cool forests where it is particularly abundant along the banks of mountain streams. One of the Maryland specimens was taken along Muddy Creek, near Swallow Falls, in a Rhododendron and hemlock forest which is typical woodland jumping mouse habitat. Handley and Patton (1947, p. 184) found that in Virginia they are most common at high altitudes among ferns, blackberry, and St.-Johns-wort in clearings surrounded by forest. The woodland jumping mouse is seldom found in open meadows, fields, or marshes where this is no heavy forest within close proximity.

This species makes no well-defined trails or runways, but utilizes the burrows of moles and larger shrews, or seeks shelter under rotting logs and fallen trees. Nests are usually placed several inches below the ground and are made of leaves and dry grass. Sometimes the entrance to the nest is closed when the animal is in the burrow.

During the colder months of the year, woodland jumping mice hibernate, and their life processes are reduced to a mininum. In the autumn they eat heavily and accumulate large stores of fat on the body to carry them over the long period of hibernation. Their hibernation, deep and prolonged, is usually half of the year.

Hamilton (1941, pp. 260–261) lists the food of the woodland jumping mouse as insect larvae (particularly lepidopterous and dipterous forms), spiders, small soil worms, centipedes, various small invertebrates, small seeds, tiny nuts, small green leaves, blueberries, raspberries, and fragments of *Asplenium* fronds.

This species normally raises but one litter a year. The gestation period is between 20 and 23 days, and from two to six young, possibly eight, comprise a litter; the most frequent number appears to be five.

Specimens examined.—Allegany County: Dans Mountain, 2. *Garrett County:* Finzel, 1; Grantsville, 5 miles SE (Savage River State Forest), 8 (Coll. U. Mich.); Muddy Greek Falls, 3 (Coll. U. Md.); Swallow Falls State Forest (along Muddy Creek), 1.

Remarks.—Although Preble (1899, p. 35) noted that the specimen he collected at Finzel showed no approach to *N. i. roanensis* (type locality: Roan Mountain, N.C.), it is my opinion that this specimen and one from Swallow Falls State Forest and eight from 5 miles SE of Grantsville show traits that are characteristic of *roanensis*. They are smaller in size and darker in coloration than typical *insignis*, and they appear to represent intergrades with *roanensis*. However, they are closer to *insignis* than *roanensis* in these characters and are herein assigned to the former subspecies.

Order CARNIVORA (flesh-eating mammals)

Family Canidae (dogs, foxes, etc.)

COYOTE

Canis latrans Say

Canis latrans Say, in Long, Account of an exped. . . . to the Rocky Mts. . . . , 1:168, 1823).

Type locality.—Engineer Cantonment, about 12 miles southeast of the present town of Blair, Washington County, Nebr., on the west bank of the Missouri River.

General distribution.—Distributed primarily west of Mississippi River, from Alaska to Central America, with the center of population in the Great Plains of the United States. The species has recently been reported from a number of Eastern States, and apparently has been expanding its range eastward. Some of the eastern populations, however, may be derived from animals that escape from captivity, particularly those populations in Southern States.

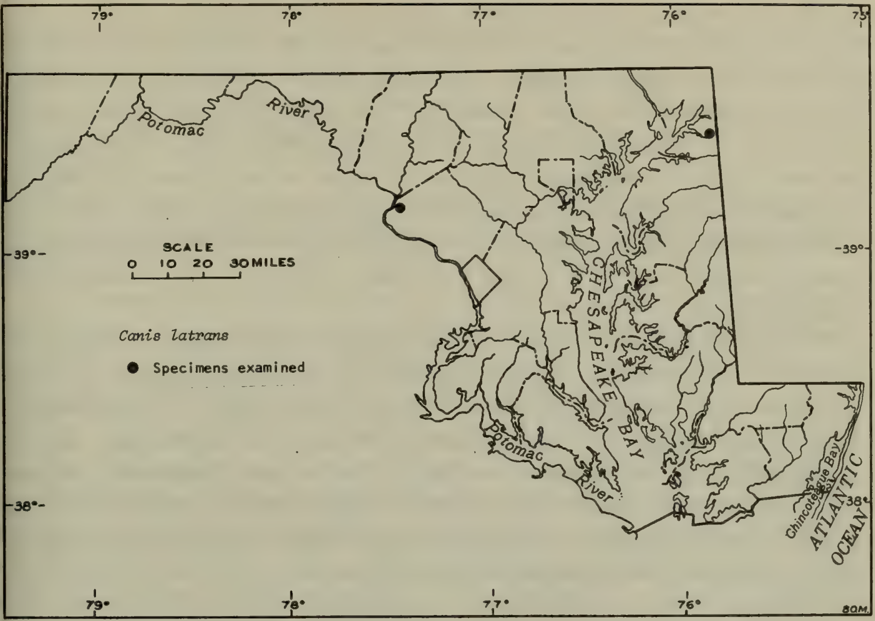

Figure 44.—Distribution of *Canis latrans*.

Distribution in Maryland.—May be expected anywhere in the State. See discussion in Remarks section.

Distinguishing characteristics.—Teeth 3/3, 1/1, 4/4, 2/3, = 42; closely resembles a small police dog, but with shorter legs, a bushier tail, and a more slender muzzle. Some feral dogs are so similar to coyotes that it is a difficult task for even an expert to distinguish them. The problem is further compounded because the coyote and dog may interbreed in the wild, although authentic reports of such crosses are scarce. There does not appear to be any certain way to distinguish coyote-dog hybrids from pure domestic dogs.

The coyote is grayish in coloration, and the dorsal hairs are tipped with black. There is a rusty or yellowish tint on the neck and along the sides, particularly on the flanks. The head is grizzled gray; the ears brownish. The feet are fulvous, and the throat and belly white. Since some domestic dogs may be similar to this in coloration, it is sometimes necessary to examine the skull to determine the species of the animal in question. The most important cranial difference between the two is that in the coyote the frontal region of the skull is always flattened, whereas in the dog it bulges to some degree. In some varieties of domestic dog this bulge is quite pronounced, in others it is less so, but it is generally more developed than in the coyote. The second most noticeable difference is found in the rostrum, which is slender and elongated in the coyote and usually shorter and more blunt in the dog. In addition, the tips of the upper canines of the coyote fall below the level of the anterior mental foramina when the jaws are closed; in the dog they terminate above these foramina. The premolar teeth in the coyote are generally widely space; in the dog they are crowded. The ventral surface of the mandibular ramus is flattened in the coyote, whereas in the dog it is generally rounded. Various indexes have been developed to express numerically some of the above-mentioned cranial differences (see Howard, 1949, p. 171; Bee and Hall, 1951, pp. 73–77; Burt, 1946, pp. 61–62).

Certain specimens exhibit a confusing combination of dog and coyote characteristics. These animals may represent hybrids, but the characteristics of known hybrids have not been adequately documented. Until the problem of hybridization between the coyote and dog is thoroughly studied it seems advisable to refer any questionable specimens to the latter species. The domestic dog is one of the most variable animals with regard to its physical structure, whereas the coyote is a very uniform one (except for size). Because of this, it is possible for the domestic dog to exhibit some coyote traits without having any admixture of coyote blood, whereas it is far less likely that a coyote would exhibit dog traits without some dog intermixture.

In the field, the coyote at a distance may resemble a gray wolf (*Canis lupus*). The coyote, however, is much the smaller animal, has a more yellowish cast to the pelage, and carries its tail lower when running. The skull of the coyote is smaller than that of the gray wolf, and more lightly built; the teeth are much smaller, and the frontal region of the skull is flat, whereas in the gray wolf it is bulging as in the domestic dog.

Both the red fox and the gray fox are less doglike in general appearance than the coyote, and both are considerably smaller in size, and different in coloration.

Measurements.—Externally the coyote ranges in total length from 1,052 to 1,320 mm. with a tail varying from 300 to 394 mm. The hind foot averages between 177 and 220 mm. (Hall and Kelson, 1959, p. 843). Animals from southwestern localities are smaller than those from farther north, and males are larger than females.

A male from 5 miles northwest of Poolesville, Montgomery County, and a female from Cecil County, near the Delaware State line, west of Middlebury, Del., have the following cranial measurements: Condylobasal length 180.4, ——; zygomatic breadth 99.8, 87.8; interorbital breadth 29.6, 31.5; length of maxillary toothrow 82.3, 78.7.

Habitat and habits.—The coyote prefers open or semiopen country. Young (Young and Jackson, 1951, p. 11) calls the coyote an "edge" animal, and believes that it has expanded its range as the forested areas of the country vanished either through natural means such as forest fires or through manmade means such as logging etc. With the clearing of the land in the Northeastern United States, the coyote probably found habitat there to its liking, and has extended its range eastward.

The habits of the coyote are thoroughly discussed by Young and Jackson (pp. 47–105). The following is compiled primarily from their findings.

The home of the coyote is usually a den which it constructs on a bank or hillside, in wheat or corn fields, under houses, shacks, drainage pipes, or in hollow logs in thickets. Often the animal makes use of a fox or skunk den, enlarging it to suit its needs.

As a rule, coyotes do not mate for life, but some pairs may remain together for a number of years. There is evidence that the female may breed when she is 1 year of age. The breeding season is from February to March or April, being earlier apparently in northern than in southern latitudes (Hamlett, 1938). The gestation period is 60 to 63 days, and females have been known to deliver as many as 17 to 19 young, although 5 to 7 is the usual number.

Sperry (1941) examined the stomachs of 8,339 coyotes from western and midwestern localities and found that the principal food of the species is animal matter, of which more than 90% consists of mammals. In addition to carrion (25.1%), the chief mammals consumed are rabbits (33.2%), rodents (17.5%), domestic livestock (13.5%), big game mammals, principally deer (3.6%), and miscellaneous mammals such as skunks, badgers, weasels, shrews, moles, foxes, raccoons, cats, etc. (1%). Birds comprise some 2.9% of the coyote's diet, and other vertebrates 0.08%. Insects account for 1% of the diet, and vegetable matter, principally wild fruit and cultivated fruit, some 1.7%. These percentages vary according to seasonal availability.

Specimens examined.–Cecil County: Near Delaware line, west of Middletown, Delaware, 1. *Montgomery County*: Poolesville, 5 miles NW, 1.

Remarks.—The coyote has been reported from nearly all of the Eastern States. It is known that the species has been extending its range eastward. Probably the coyotes of our Northeastern States are a result of the natural expansion of the range of the species. On the other hand, coyotes have been introduced accidentally, or on purpose, into some of the Southeastern States, and present populations in those States may derive from these artificial introductions.

The first coyote discovered in Maryland was taken on 5 February 1921, on a farm 5 miles NW of Poolesville, Montgomery County. Jackson (1922, p. 187) in a discussion of this animal says:

The question naturally arises as to how a coyote reached this eastern locality. It is, of course, impossible to say definitely. The animal probably escaped from captivity. Or it may represent an extreme eastern extension of the geographic range of coyotes. There is no direct evidence for or against either of the suppositions. It is known that the range of the coyotes has gradually extended northward and eastward, but it would seem hardly probable that the species has, as yet, ingressed a region as far east as central Maryland.

The area in which this animal was taken was transversed by a major east-west arterial highway (U.S. Route 40) and it seems highly likely that the animal was brought into the area artifically. This view is supported by the fact that nearly 40 years elapsed before another coyote was discovered in Maryland. If the Montgomery County coyote really represented a southward or eastward extension of the range of the species, there probably would have been at least occasional reports of their presence in the State in later years. As it is, not until 21 April 1961 was another coyote discovered in Maryland. On this date, a coyote was shot in Cecil County near the Delaware border by employees of the Delaware Board of Game and Fish Commissioners. Here again, the area where the animal was shot is near a major east-west highway system and not very distant from the cities of Baltimore, Wilmington, and Philadelphia. It seems likely that the animal was brought east as a pet, and either was released or escaped from captivity. On the other hand, the increasing number of reports of coyotes from New England, New York, and other Northeastern States make it more probable now than it was 40 years ago that the species has reached Maryland in its natural range expansion. It is still, nevertheless, impossible to say definitely.

RED FOX

Vulpes vulpes fulva (Desmarest)

Canis fulvus Desmarest, Mammalogie . . ., pt. 1, p. 203, *in* Encyclopédie méthodique . . . 1820.

Type Locality.—Virginia.

General distribution.—Most of the Eastern United States, from southern Maine, southern Ontario and Wisconsin, south to Alabama, Georgia, and the Carolinas.

Distribution in Maryland.—Occurs in all sections of the State.

Distinguishing characteristics.—Dental formula as in *Canis;* similar in size and general characteristics to a small dog; nose sharply pointed; ears prominent and erect; tail long and bushy, fulvous, but strongly streaked with black, and always with a white tip; pelage long and soft; coloration rusty on face and occiput, usually mixed with whitish; upper parts colored bright yellowish red, or fulvous, darker on the median line, with the rump grizzled with whitish; cheeks, chin,

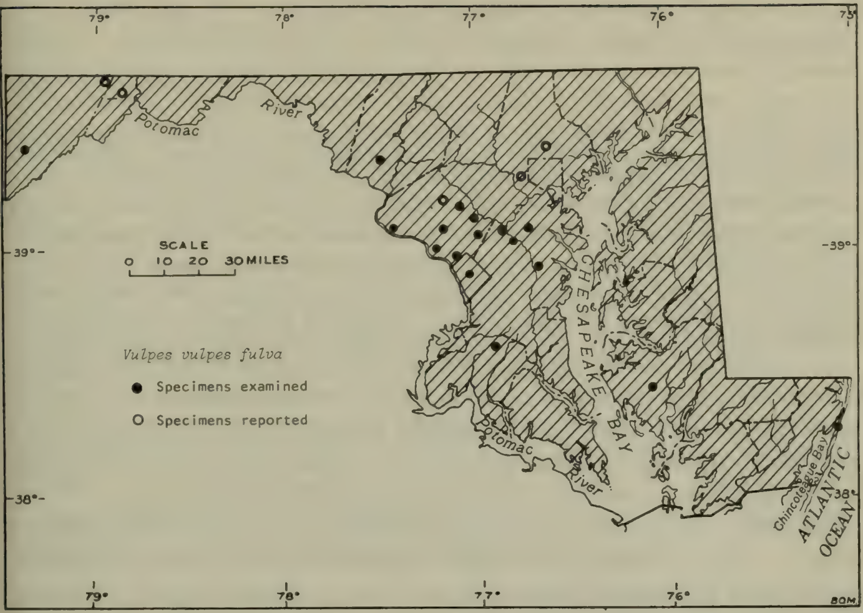

FIGURE 45.—Distribution of *Vulpes vulpes fulva.*

throat, and a band down the abdomen white; feet and outside of ears black.

Cranially, this fox differs from the gray fox (*Urocyon*) in that the temporal ridges enclose a narrow V on the top of the skull, whereas in the latter they are distinctly lyrate in shape; the upper incisors are lobed, in contrast to the unlobed condition in *Urocyon.*

Measurements.—Three adult males from Montgomery County have the following external measurements: Total length 1030, 1000, 995; tail 370, 372, 360; hind foot 170, 165, 160; ear 83, 86, 85. Cranial measurements of seven adults from Montgomery County are as follows: Basal length 139.7 (133.8–143.6); zygomatic breadth 72.0 (69.7–74.0); postorbital constriction 23.9 (22.0–28.8); alveolar length of upper maxillary toothrow 61.8 (59.5–63.4).

Females average smaller than males in size.

Habitat and habits.—The red fox is cosmopolitan in its distribution, except that it is not generally found in dense forests and woods. It prefers rolling farmland, sparsely wooded areas, brushlands, and dense weed patches, usually in the vicinity of a stream or lake.

The species is now abundant in all sections of the State, although at one time it apparently was not found here. According to Mansueti (1950, pp. 27–28), the early American settlers hunted the gray fox (*Urocyon cinereoargenteus*). The Indians were unanimous in claiming that before the coming of the Europeans there were no red foxes in the area. Sometime around 1650, red foxes were imported from England and released along the Eastern Shore of Maryland. These foxes apparently thrived and by the late 1670's had spread down the peninsula into Virginia. Today the species is widely distributed in Maryland, and is found even within the limits of metropolitan areas such as Baltimore and Washington, D.C. Whether the fox which now occurs throughout the State is the variety introduced by the English, or the native eastern North American form which has extended its range southward, will be discussed under the Remarks section.

The red fox is extremely abundant in some areas of the State. According to the League of Maryland Sportsmen (Rally Sheet 4(10), p. 6, December 1946) 79 were caught in a 5-week period at Mount Savage, Garrett County, in 1946. At the eastern end of the State on the outer barrier beach of Assateague Island, it is also abundant, and does some damage to nesting birds and their eggs. This species still roams in Rock Creek Park in the heart of Washington, D.C.

The food of the red fox varies from season to season. Llewellyn and Uhler, (1952, p. 198) found that in their Maryland sample, comprising mostly November, December, and January animals, 17 percent of the food was plant material consisting of fruits, berries, and other plant items. Persimmon, pokeberry, and wild grape were most often consumed, while in the fall beechnuts were heavily utilized. Apple, pear, and corn were eaten to a minor extent. The bulk of the red fox's food consists of animal foods, the most important part of which appears to be rabbit. Also consumed are rodents (meadow mice, muskrats, pine mice, gray and flying squirrels, house mice) and shrews. Birds and occasionally insects are eaten. In the spring and summer months the food consists of woodchucks, poultry, rabbits, small rodents, birds, snakes, turtles, eggs and varying amounts of vegetable matter particularly raspberries and blackberries. There is no question that red foxes prey to some extent on domestic livestock, particularly poultry when it is not properly housed. Sometimes red foxes may become quite bold. Vernon Bailey (unpublished report in files of U.S. Fish and Wildlife Service, 25 April 1936) tells of a pair raiding the henhouse of a farm in Brookville, Montgomery County; they were so bold that they often raided in broad daylight and took the hens before the eyes of their owners.

The red fox is monogamous and is believed to remain mated for life. The species is monestrous, with one season a year. Most matings take place in late January or February, and the gestation period is between 49 and 55 days. Litter size varies between one and eight, with four or five being the usual number.

The breeding or family den of the red fox is nearly always in a burrow, often that of a woodchuck, and is more often located in more open land, such as a pasture, fence border, or cultivated field. Vernon Bailey (unpublished report, 1936) described one such den at Brookeville as follows:

> The den had four openings, or doorways, 10, 15, and 20 feet apart, really the old doorways of a woodchuck den enlarged to fox size. Two opened out on each side of a big chestnut log, 3 or 4 feet in diameter. The burrows had been dug out by the foxes to about twice the diameter of the woodchuck burrows and enlarged to a comfortable fox nest room 20 feet back from the main entrance and 10 feet back from the other doorways. They ran 3 or 4 feet below the surface through hard clay full of rocks that necessitated many crooks and turns but ran uphill so the nest chamber was actually higher up than the actual doorway. All of the burrows centered at the nest, beyond which the original woodchuck burrow extended about 10 feet further but did not come to the surface.
>
> There was no nest material in the nest chamber, but semidry earth made a comfortable bed for the young foxes with their dense woolly coats, and a uniform temperature that I should guess was around 55° F. gave them a healthy home in the den.

Both parents hunt for food to provide for the young. Bailey describes the food found in the den at Brookeville:

> Much food had been brought into the den by the parent foxes. One white rooster had been all eaten but the wings and head and telltale feathers scattered around the doorway; one large house rat was lying near the doorway and two others were found in the nest chamber and parts of four others in the pantry, an excavation half full of food at one side of the upper entrance. It was about four feet below the surface and so cool that all of the meat was fresh though some of it several days old. From this were taken out part of a cottontail, half a crow, and a mouse.

Specimens examined.—Anne Arundel County: Fort George G. Meade, 1; Priest Bridge (near), 1. *Charles County:* Waldorf, 1. *Dorchester County:* Blackwater National Wildlife Refuge, 9. *Frederick County:* Jefferson, 2. *Garrett County:* Oakland, 1. *Howard County:* no exact locality, 1. *Montgomery County:* Bethesda, 1; Brookeville, 1; Fairland, 1; Poolesville, 5 miles SW, 3; Potomac, 1; Rockville, 1; Sandy Spring, 1; no exact locality, 1. *Prince Georges County:* Laurel, 5; Patuxent Research Center, 4. *Worcester County:* Ocean City, 3 miles S (Assateague Island), 2. *District of Columbia:* 3.

Other records and reports.—Allegany County: Mount Savage (League of Maryland Sportsmen, Rally Sheet 4(10), p. 6, December 1946). *Baltimore County:* Loch Raven (Kolb, 1938); Patapsco State Park (Hampe, 1939, p. 6). *Garrett County:* Finzel (E. A. Preble in field report). *Montgomery County:* Laytonsville (rabid red fox reported in Washington Evening Star, 28 December 1956); Plummers Island (Goldman and Jackson, 1939, p. 132).

Remarks.—It is well established that the red fox was either scarce or did not occur in Maryland prior to the colonization of the State by Europeans. Churcher (1959, p. 514) states that "a red fox was native to North American north of Lat. 40° N or 45° N, but was either scarce or absent from most of the unbroken mixed hardwood forests (to the south of this) where the gray fox was paramount."

The early Maryland colonists originally hunted the gray fox, but apparently at a very early date the European red fox was imported for hunting purposes and was released at various localities, one of which was the Eastern Shore. Since the red fox is now found throughout the whole of Maryland, as well as much of the Southeastern United States, the question arises whether these southern red foxes are the European variety or native North American red foxes which have extended their range southward.

Churcher (1959, pp. 513–520) has established that the European red fox and the North American red fox are subspecies of the same species *Vulpes vulpes*, the various subspecies intergrading in several major characters (shape of upper first molar, breadth of rostrum, development of sagittal crest) from western Europe, through Siberia, Alaska, Canada, to eastern North America. The two end products, the western European red fox and the eastern North American red fox are, however, quite different animals even if only subspecifically distinct. The European red fox is larger and has a more robust skull than its eastern American relative. It also has a shorter, broader rostrum, a relatively narrower interorbital region, and a well-developed sagittal crest which forms a distinct ridge along the top of the skull. In the native eastern American red fox the sagittal crest is occasionally developed but usually not into a conspicuous ridge. It narrowly diverges anteriorly into the temporal ridges which enclose a conspicuous V on the top of the skull. This conspicuous V formed by the temporal ridges is usually not as well developed, or is lacking, in the European form. The shape of the first upper molar also differs in the two subspecies. In the European variety this tooth is large and square in general outline, the buccal cingulum is rounded, the talon broad, and the mesial face convex. In the American form, the tooth gives the general appearance of being elongated laterally; the buccal face is deeply indented, the talon elongated, the mesial and distal faces concave, and there is a small protoconule.

All the Maryland red foxes (and those from farther south) that I have examined show the characters of the native eastern North American form, and there seems to be no indication of intermixture with European fox blood. In fact, Maryland specimens appear to be indistinguishable from those of Wisconsin, Michigan, southern Ontario, and New England, where I presume there was little or no importation of European stock by early colonists. It is possible that with the clearing of land in the Southeastern United States, the habitat became well suited to the native American red fox, which then invaded the area from the north. The European red foxes, which may never really have been well established in the United States, were perhaps swamped by the influx of native American foxes and left no recognizable characteristics on the present fox population in Maryland or elsewhere in the Southeast.

GRAY FOX

Urocyon cinereoargenteus cinereoargenteus (Schreber)

Canis cinereo argenteus Schreber, Die Saugtheire . . ., Thiel 2, Heft 13, pl. 92, 1775.

Type locality.—Eastern North America.

General distribution.—Distributed from southern New York and Lower Peninsula of Michigan, south to South Carolina and Tennessee, west to eastern Illinois.

Distribution in Maryland.—Occurs in all sections of the State. It is more abundant, however, in the rolling hilly country of the Piedmont, Ridge and Valley, and Allegheny Mountain sections than in the low, flat, mashy country of the Eastern Shore section.

Distinguishing characteristics.—Dental formula as in *Canis;* coloration grizzled gray above with hairs banded with black and grayish white; inner sides of legs, sides of belly, neck, and band across chest reddish brown; belly and throat white; chin black; underfur soft and wooly, overlaid with short, coarse guard hairs; tail bushy, laterally compressed with a concealed mane of stiff black hairs on its upper side, near the base; legs short, feet equipped with well-curved claws that adapt the animal for climbing; skull with temporal ridges whose divergent branches enclose a lyrate area and never coalesce to form a distinct, sharp central sagittal crest.

This fox is somewhat smaller in size, has shorter legs, and is differently colored, than the red fox.

Measurements.—An adult male from Washington, D.C., has external measurements as follows: Total length 996; tail 356; hind foot 143; ear 71. The animal weighed 10½ lbs.

Six adults of both sexes from Laurel, Prince Georges County, have the following cranial measurements: Basal length 112.7 (110.8–114.0); zygomatic breadth 67.0 (63.0–70.8); interorbital breadth 24.9 (23.8–27.3); alveolar length of maxillary toothrow 51.6 (50.9–52.9).

There does not appear to be any appreciable size difference between the sexes.

Habitat and habits.—This animal is essentially a southern and western species that has apparently only recently invaded this northern portion of its range (Hamilton 1943, p. 176). It prefers timbered and rocky regions. Because of its relatively short legs, it has no great

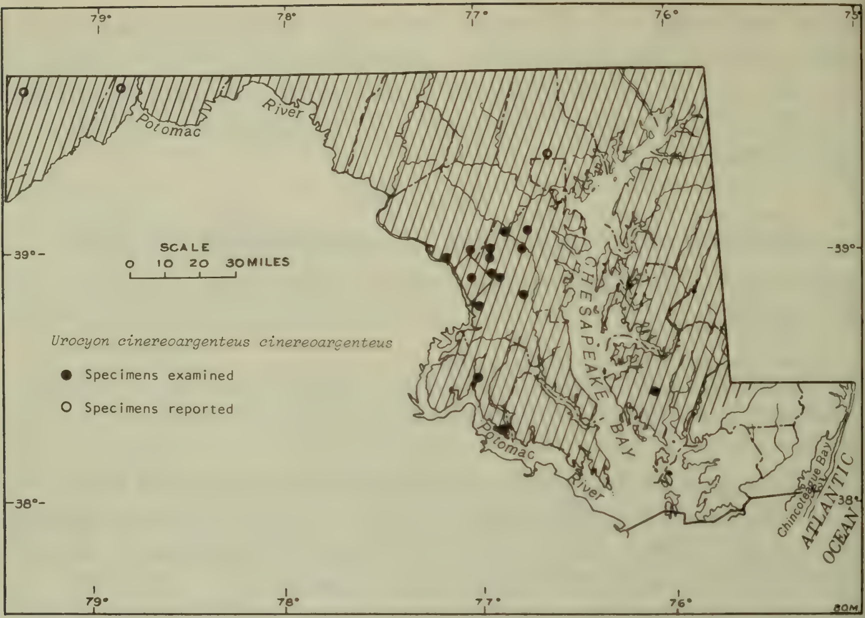

FIGURE 46.—Distribution of *Urocyon cinereoargenteus cinereoargenteus.*

speed and would perhaps have difficulty surviving in wide open areas. On the other hand, it is quite at home in the trees, being more arboreal than the red fox. For protection, it depends to some extent on rocky or brushy cover to which it can retreat, or forests where it can quickly climb a tree to escape a predator. Of 60 gray foxes trapped at the Patuxent Research Center, Prince Georges County, in the 1940's, the majority were taken in hedgerows and margins habitat, and most of the others in bottomland forests (Uhler and Llewellyn, 1952, p. 84).

This species selects a hollow tree or log for a den; occasionally it may use a burrow in the ground. It breeds but once a year, usually in February. Young are born from March to May and may number from two to seven, with the average being four. Both parents take part in caring for the young.

The food of the gray fox varies from season to season. Studies at the Patuxent Research Center (Llewellyn and Uhler, 1952, p. 199) indicate that in late fall and early winter approximately 30 percent of the gray fox's food is plant material, while about 70 percent is animal. Of the plant food consumed, persimmon was the most important item, while corn, pear, apple, and beechnut were also taken. Rodents were by far the most important animal food, but rabbits, birds, and insects were also consumed. Hamilton (1943, p. 177) lists rabbits as the most important food for the species. He also lists birds, small mammals, particularly field mice, deer mice, wood rats, and shrews, snakes, turtles, and their eggs, lizards, insects, apples, beechnuts, corn, grapes, hickory nuts, persimmons, carrion, wild cherries, and grasses as additional food items.

The species is abundant in the Piedmont, Ridge and Valley, and Allegheny Mountain sections. Forty gray foxes were taken in only 5 weeks in 1946 at Mount Savage, Garrett County (League of Maryland Sportsmen, Rally Sheet 4(10), p. 6, December 1946). The species, however, is not abundant in the Eastern Shore section. In fact, the first gray fox ever taken on the Blackwater National Wildlife Refuge, Dorchester County, was obtained as late as 22 October 1943. Apparently much of the Eastern Shore section is too low, flat, and marshy for the animals' liking.

Specimens examined.—Anne Arundel County: Fort George G. Meade, 1. *Charles County:* La Plata, 1; Rock Point, 1. *Dorchester County:* Blackwater National Wildlife Refuge, 1 (baculum). *Montgomery County:* Plummers Island, 1; Silver Spring, 1. *Prince Georges County:* Beltsville, 1; Berwyn, 2; Landover, 1; Largo, 1; Laurel, 11; Marlboro, 1; Oxon Hill, 1; Patuxent Research Center, 11.

Other records and reports.—Allegany County: Mount Savage (League of Maryland Sportsmen, Rally Sheet 4(10), p. 6, December 1946). *Montgomery County:* Cupids Bower (Bailey, 1923, p. 123.).

Family URSIDAE (bears)

BLACK BEAR

Ursus americanus Pallas

Ursus americanus Pallas, . . . Spicilegia zoologica, . . . fasc. 14: 5, 1780.

Type locality.—Eastern North America.

General distribution.—Wooded areas of North America, from Newfoundland to Alaska, and south into central Mexico.

Distribution in Maryland.—The black bear was once distributed throughout the State, but today is on the verge of extirpation and is found only in restricted areas in the Ridge and Valley and Allegheny Mountain sections.

Distinguishing characteristics.—Teeth 3/3, 1/1, 4/4, 2/3, = 42; largest wild mammal in Maryland; toes armed with strong claws; normal color both above and below black or very dark brown, except for cinnamon patch across muzzle and sometimes a white blotch on throat; pelage harsh and coarse. The black bear is so familiar as to scarcely need description.

Measurements.—"Total length, adult males, 1375 to 1780 mm. (54 to 70 in.); tail, 90 to 125 mm. (3.5 to 5 in.); hind foot, 215–280 mm.

(8.5 to 11 in.). Weight, adult males, 250 to 500 pounds, rarely 600 pounds or more, normally 300 to 400 pounds. Skull, adult males, length, 270 to 298 mm.; width, 158 to 185 mm. Total length, adult females, 1270 to 1475 mm. (50 to 58 in.); tail 80 to 115 mm. (3 to 4.5 in.); hind foot, 190 to 240 mm. (7.5 to 9.5 in.). Weight, adult females, 225 to 450 pounds. Skull, adult females, length 255 to 285 mm.; width, 148 to 172 mm." (Jackson, 1961, p. 313).

Habitat and habits.—The black bear prefers heavily wooded areas, and is now confined to the wildest and most inaccessible forests of the Allegheny Mountain section. Individuals may occasionally visit well-populated agricultural areas, but they usually do not remain in the neighborhood of humans for any length of time.

Except for females with cubs, the black bear is solitary in habits. It is nocturnal but usually does not wait until full darkness to venture forth; occasionally an individual may be seen abroad in the daytime. These bears remain dormant from about the end of November or early December until March or April, usually in a cavity dug under an overturned tree, most often at the roots. Sometimes other sites are chosen, such as a cave in rocks, a hollow tree, or dense thickets.

The female gives birth in January or February; the gestation period is about 225 days. One to five young may comprise a litter, but the usual number is two. Black bears normally breed only every other year.

The black bear is an omnivorous animal, consuming a wide variety of foods. It is especially fond of fruits and eats large quantities of blueberries, blackberries, strawberries, and raspberries. It also consumes quantities of mice, insects, and fish and occasionally will kill and devour sheep and pigs. In the autumn, when nuts are available, it feeds extensively on acorns and beechnuts. In addition, it will occasionally eat grass, roots, and fungi.

Remarks.—Mansueti (1950, pp. 14–16) has thoroughly investigated the former and present distribution of this species in Maryland. According to him, the black bear was at one time distributed throughout the State and was plentiful. Early settlers considered it the bane of their existence. Today the black bear still exists in restricted portions of the western part of the State, but in the past 2 or 3 decades it has been on the verge of extinction. A 1937 report by the U.S. Bureau of Biological Survey (Big-Game Inventory of the United States, 1937, Wildlife Research and Management Leaflet BS–122, January 1939) placed the total number of bears in Maryland at 150. The 1938 summary (Big-Game Inventory of the United States, 1938, U.S. Bureau of Biological Survey, Wildlife Leaflet BS–142, August 1939) placed the number at 50. By 1946 (Big-Game Inventory of the United States, 1946, U.S. Fish and Wildlife Service, Wildlife Leaflet

303, March 1948) the estimate was down to 25; in 1951 (Inventory of Big-Game Animals of the United States, 1950 and 1951, U.S. Fish and Wildlife Service, Wildlife Leaflet 342, October 1952) to 20; and by 1956 to 12.

Bears are still occasionally seen in Allegany and Garrett Counties. Theodore A. Bookhout, formerly with the University of Maryland's Natural Resources Institute, has informed me of several recent sightings. In the fall of 1963, one was seen near Murley's Branch, a few miles south of Flintstone, Allegany County; in October 1963, one was seen on Maryland Route 55, approximately 2 miles north of Corriganville, Allegany County; on January 3, 1964, bear tracks were seen on Wagner Road just north of Oldtown, Allegany County.

As Mansueti (1950, p. 16) notes, however, western Maryland is becoming more densely populated and the extensive forests are being laid waste, and the black bear will disappear mainly because it is unwanted. At most it will remain in only the most remote and inaccessible of Maryland wildlife sanctuaries.

Family PROCYONIDAE (raccoons, coatis, etc.)

RACCOON

Procyon lotor lotor (Linnaeus)

[*Ursus*] *lotor* Linnaeus, Syst. nat., ed. 10, 1: 48, 1758.

Procyon lotor maritimus Dozier, J. Mammal., 29(3): 286, August 1948. (Type locality: Blackwater National Wildlife Refuge, Dorchester County, Md.)

Type locality.—Pennsylvania (fixed by Thomas, Proc. Zool. Soc. London, p. 140, March 1911).

General distribution.—"Nova Scotia, southern New Brunswick, southern Quebec, and southern Ontario, south through the eastern United States to North Carolina from the Atlantic coast west to Lake Michigan, Indiana, southern Illinois, western Kentucky and probably eastern Tennessee." (Goldman, 1950, p. 33.)

Distribution in Maryland.—Common in all sections of the State, but particularly abundant in the Eastern Shore section.

Distinguishing characteristics.—Teeth 3/3, 1/1, 4/4, 2/2, = 40; size medium; form robust; fur long and coarse; coloration of upper parts grizzled gray, brownish, and blackish, there being considerable individual variation; sides paler than upper parts; under parts dull grayish brown, tinged with yellowish gray or white; black band, or mask, extends through eyes and across cheeks; remainder of face yellowish gray; tail alternately banded brownish gray or blackish and yellow, with five to seven dark rings, always terminating in a dark band.

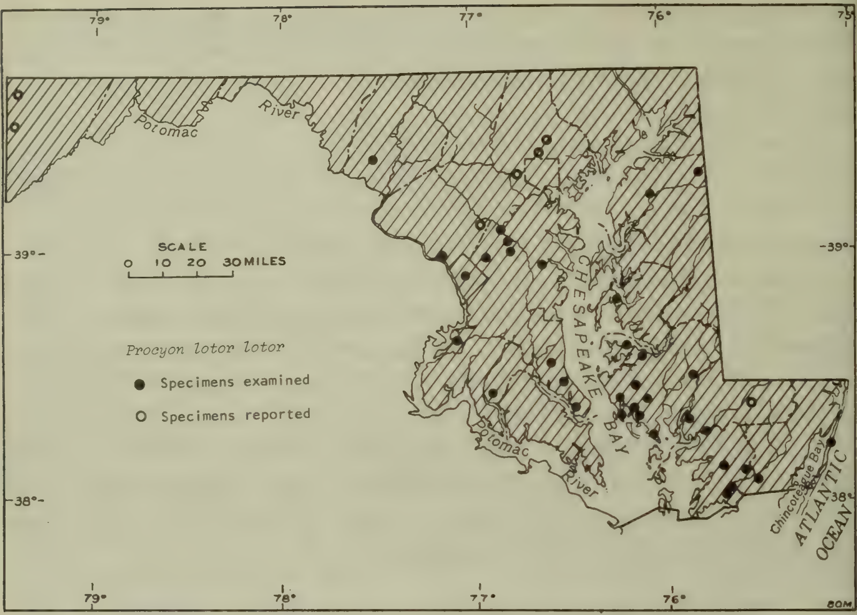

FIGURE 47.—Distribution of *Procyon lotor lotor*.

The racoon is easily distinguished from all other Maryland mammals by the dark facial mask and the long-haired tail ringed with black and yellow.

Measurements.—External and cranial measurements of four adult females from the Blackwater National Wildlife Refuge, Dorchester County, are: Total length 749.5 (718–762); tail 236.7 (210–254); hind foot 108 (102–114); condylobasal length of skull 110.9 (107.1–114.2); zygomatic breadth 67.1 (62.7–69.7); postorbital breadth 23.3 (22.5–23.8); length of maxillary toothrow 41.3 (39.9–43.8); breadth of rostrum at incisors 23.7 (23.1–24.2). External measurements of three and cranial measurements of four adult males are: Total length 736, 736, 762; tail 229, 229, 254; hind foot 102, 102, 102; condylosabal length of skull 114.1 (110.9–117.9); zygomatic breadth 67.4 (64.9–69.9); postorbital breadth 22.5 (21.0–24.7); upper maxillary toothrow 26.1 (25.3–26.5).

Three adult males and three adult females from Laurel, Prince Georges County, measure cranially: Condylobasal length 109.6, 112.7, 111.7, 106.3, 104.4, 108.8; zygomatic breadth 67.4, 67.8, 74.9, 67.7, 68.4, 65.1; postpalatal breadth 24.2, 22.1, 23.5, 22.1, 22.4, 23.2; length of maxillary toothrow 40.9, 41.6, 41.1, 40.7, 39.0, 40.1; breadth of rostrum at incisors 25.6, 25.1, 26.1, 23.5, 22.5, 22.8.

Habitat and habits.—The raccoon is cosmopolitan in habitat preference, being found in woods, swamps, and marshes, including salt-water marshes of the Atlantic barrier beaches. Uhler and Llewellyn (1952, p. 83) report that at the Patuxent Research Center, near Laurel, Prince Georges County, the outstanding habitat type was bottomland forest, followed by cultivated fields (mainly those with corn), hedge rows and wood margins, particularly if leading to cornfields. Raccoons were also abundant around marshy lake borders and in swamps.

The raccoon is a very adept climber. Although it usually makes its home in a hollow tree, it sometimes will utilize a fissure in a cliff, or a hole among rocks. Raccoons rapidly diminish in numbers when trees are cut over, and will either die off or leave the area after all the trees are gone.

The raccoon is nocturnal, and forages for its food after sunset. Its diet consists of fish, crayfish, frogs, and mussels, as well as poultry, mice, birds, eggs, reptiles, and insects. In season, it eats considerable amounts of vegetable matter such as nuts, fruits, berries, and corn.

In more northern climates the raccoon hibernates, but in Maryland it remains active the year round except in the coldest portions of the western part of the State. The species breeds in January and February, and some 63 days later females give birth to two to six young. The cubs are born blind and remain so for about 19 days; they suckle for 2 months, and remain in the family circle through the winter.

Remarks.—Maryland raccoons differ in no significant way from Pennsylvania and New York specimens. Dozier (1948a, p. 286) separated the raccoons inhabiting the marshes of the Delmarva Peninsula from those living in the surrounding woods as a distinct subspecies, *Procyon lotor maritimus*. I have examined the type of this race, as well as the series designated by Dozier as representing it, and am unable to separate it from raccoons inhabiting other parts of Maryland. All the diagnostic characters mentioned by Dozier (paler coloration; longer but more sparse guard hairs; much smaller size; shorter, more pointed and less prominently banded tail; relatively shorter caudal vertebrae; smaller and more distinctly curved baculum; and various cranial characters) are either within the limits of individual variation of *P. l. lotor*, or are so slightly marked that I have been unable to distinguish them. Consequently, I consider *Procyon lotor maritimus* Dozier to be a synonym of *Procyon lotor lotor* (Linnaeus).

Specimens examined.—Anne Arundel County: Rutland, 1. *Calvert County:* Prince Frederick, 1; St. Leonard (near), 1; Sollers, 9. *Charles County:* Marshall Hall, 1; Newport, 1. *Dorchester County:* Blackwater National Wildlife Refuge, 69; Cambridge, 1; Castlehaven Point, 3; Crapo, 1; Crocheron, 1; Golden Hill, 2; House Point, 11; Kirwan's Neck, 2; Meekins Neck, 1; Punch Island, 6; Robbins (near), 1; Shorters Wharf, 1; Vienna, 1; Worlds End Creek, 1. *Frederick*

County: Jefferson, 2. *Kent County:* Chestertown, 2; Millington (4 miles NE), 1. *Montgomery County:* Cabin John, 1. *Prince Georges County:* Bowie, 1; Branchville, 1; Laurel, 39; Patuxent Research Center, 4. *Somerset County:* Cokesbury, 4; Marumsco, 3; Rehoboth (near), 2; Westover, 2; Whitehaven (across Wicomico River from), 3. *Talbot County:* St. Michaels, 1. *Wicomico County:* Bivalve (near), 1; Whitehaven, 1. *Worcester County:* Assateague Island, 1; Pocomoke City (vicinity), 17. *District of Columbia:* 1.

Other records and reports.—Baltimore County: Bare Hills–Lake Roland area (Bures, 1948, p. 66); Loch Raven (Kolb, 1938); Patapsco State Park (Hampe, 1939, p. 5). *Garrett County:* Blooming Rose (Browing, 1928, p. 26); Cranesville Pine Swamp (Mansueti, 1958, p. 83). *Montgomery County:* Burtonsville (Herman et al., 1957, p. 113–114); Plummers Island (Goldman and Jackson, 1939, p. 132). *Wicomico County:* Salisbury, a few miles east (Kilham and Herman 1955, p. 499).

Family MUSTELIDAE (weasels, skunks, otters, etc.)

ERMINE

Mustela erminea cicognanii Bonaparte

Mustela cigognanii [*sic*] Bonaparte, Charlesworth's Mag. Nat. Hist., 2:37, 1838.

Type locality.—Eastern United States.

General distribution.—Southeastern Ontario, southern Quebec, and Maine, south through extreme northeastern Ohio and Pennsylvania into Maryland.

Distribution in Maryland.—Probably very rare in the Allegheny Mountain, Ridge and Valley, and Piedmont sections, and absent from the Western Shore and Eastern Shore sections. The species is most numerous in the coniferous forests of the northern portion of its range, but even in the north it is uncommon in coastal regions and consequently it probably does not occur in Maryland's coastal plain. It has been reported from the State only once.

Distinguishing characteristics.—Teeth 3/3, 1/1, 3/3, 1/2, = 34; size medium; body long and slender; legs short; tail moderately short, averaging about 35 percent of head and body length, well haired and slightly bushy, tipped with black above and below; coloration of upper parts in summer dark brown extending to the outer parts of the legs and feet; color of underparts whitish, usually tinged with yellow; winter coloration white except for tip of tail which remains black.

This species resembles the long-tailed weasel (*Mustela frenata*) in general appearance and in coloration, but is considerably smaller, and shorter tailed. When using size as a criterion in separating the two species, it is necessary to take into account the sex of the individual.

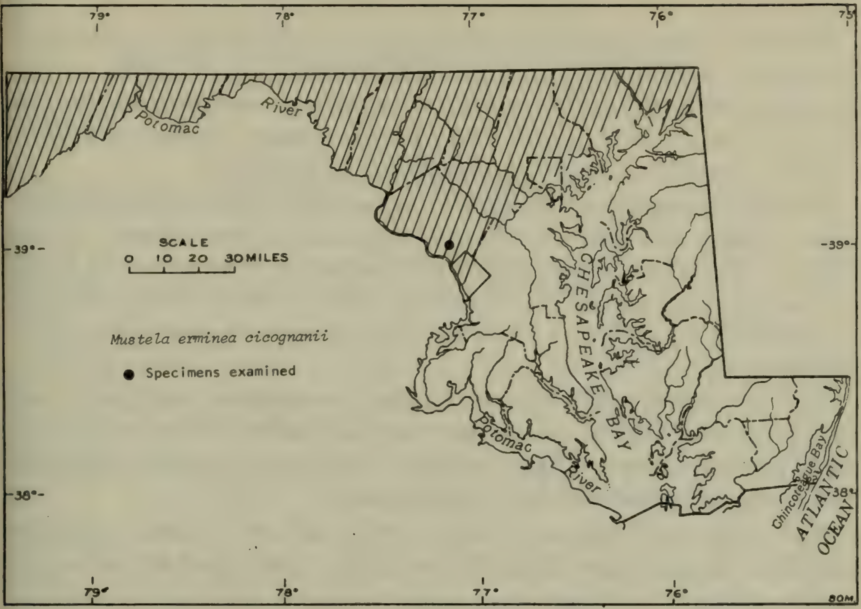

FIGURE 48.—Distribution of *Mustela erminea cicognanii.*

Male and female long-tailed weasels are larger than male and female ermines, but since the males in both species are larger than the females, a large male ermine may approach in size a small female long-tailed weasel.

Measurements.—Hall (1951, p. 119) gives the averages and extremes of external measurements of seven adult and subadult males from New York and Pennsylvania as follows: Total length 266 (240–295); length of tail 74 (66–80); length of hind foot 36 (33–39). He gives the external measurements of 12 adult and subadult females from Maine and the area south to central Pennsylvania as: Total length 243 (225–260); length of tail 63 (55–72); length of hind foot 29.8 (26–32).

Some cranial measurements given by Hall (1951, pp. 434–435) of nine adult and subadult males from New York and Pennsylvania are: Basilar length (of Hensel) 35.7 (33.8–37.6); zygomatic breadth 20.3 (19.0–20.6); interorbital breadth 8.6 (7.7–8.9); mastoidal breadth 18.2 (17.3–18.8). Four adult and subadult females from New York and Pennsylvania measure cranially: Basilar length (of Hensel) 32.4 (31.4–33.3); zygomatic breadth ——, ——, 17.5, 18.0; interorbital breadth 7.5 (7.2–7.8); mastoidal breadth 15.7 (average of 3, 15.3–16.0).

Vasquez (1956, p. 114), who collected the only Maryland record of this species, says that no external measurements are available for the specimen, but he does give the following cranial measurements for the female: Condylobasal length 38.1; basilar length (of Hensel) 34.3; mastoidal breadth 17.1; depth of skull at first molars 9.1.

Habitat and habits.—This animal is most abundant in the northern United States and Canada where it inhabits the deep spruce stands. In the southern part of its range it is often encountered in brushy fields and hedgegrows, and it is particularly fond of stone walls, where it can elude its enemies and catch the small mammals and birds which form its prey.

This weasel generally does not make its own home, but prefers to occupy the chambers of some other mammal, most often a chipmunk's cavity beneath a stump or pile of rocks. Its nest is composed of fur and feathers from the animals on which it feeds.

According to Hamilton (1943, p. 136) all the evidence suggests that these weasels mate in the early summer, and the fertilized eggs, after undergoing a short development remain quiescent for several months. Embryonic development continues in the late winter, and the four to nine young are born usually in mid-April. Hamilton states that the male weasel assists in bringing food to the young during their infancy and that there is much evidence that weasels remain paired throughout the year.

Hamilton (1933b, p. 333) reports fall and winter food of 191 ermine in New York State as composed of the following: Meadow mice 35.7 percent; undetermined mammals (principally mice) 16.3 percent; short-tailed shrews 15.1 percent; white-footed mice 11.4 percent; rabbits 9.0 percent; long-tailed shrews 4.9 percent; rats 4.4 percent; and chipmunks 3.6 percent. In addition, birds comprised some 2.1 percent, and reptiles and amphibians 1.2 percent of the fall and winter food of weasels (354 *Mustela erminea* and *Mustela frenata*).

Remarks.—This species has been recorded only once from Maryland. Vazquez (1956, pp. 113–114) reports that a cat killed an ermine on the heavily wooded grounds of the Honeywell School, 4 miles northwest of Bethesda, Montgomery County, on 27 May 1954. Prior to this, Maryland was considered far south of the normal range of the ermine, and it is possible that the animal escaped from captivity. Vazquez states that the coloration is peculiarly grayish, and that its cranial measurements are slightly larger than those of female *Mustela erminea cicognanii* and approach those of males of this race. The skin and skull of the specimen are in Vazquez' private collection and I have not examined them.

LONG-TAILED WEASEL

Mustela frenata noveboracensis (Emmons)

Putorius Noveboracensis Emmons, a report on the quadrupeds of Massachusetts, p. 45, 1840.

Type locality.—Williamstown, Berkshire County, Mass.

General distribution.—From Wisconsin east through Michigan, southwestern Ontario, southern Quebec, and southeastern Maine, south through the eastern United States to North Carolina, western South Carolina, northern Georgia, and Alabama, west to the Mississippi and St. Croix Rivers.

Distribution in Maryland.—Occurs in all sections of the State.

Distinguishing characteristics.—A large weasel, similar in coloration and general appearance to the ermine, but larger and with a longer tail. It is generally believed that except in the coldest portions of the Allegheny Mountain section, most Maryland long-tailed weasels remain in brown pelage the year round, and the majority of winter-killed specimens from Maryland that I have examined are in brown pelage. There is, however, one male from Gaithersburg, Montgomery County, and another from Patuxent, Prince Georges County, in the National collections that are entirely white except for the customary black tail tip.

Male long-tailed weasels are strikingly larger than females. So pronounced is this secondary sexual trait that some early writers

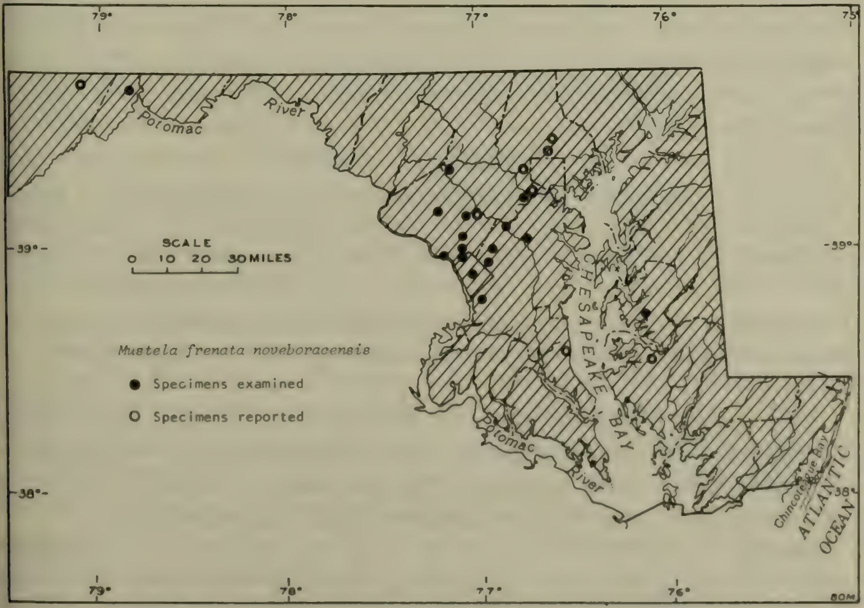

Figure 49.—Distribution of *Mustela frenata noveboracensis.*

thought the two sexes must represent distinct species. Since the female long-tailed weasel is so small, it is possible to mistake her for an ermine, and due allowance must be made for sex when separating these species on the basis of size.

Measurements.—External measurements of 12 adult males from various parts of Maryland are: Total length 382 (340–429); tail 131.6 (110–155); hind foot 48 (34–48). Seven females from various parts of the State have the following external measurements. Total length 286.6 (253–315); tail 93.1 (80–122); hind foot 34 (32–38).

Cranial measurements of 10 adult males from Laurel, Prince Georges County, are: Basilar length 42.7 (40.8–44.3); zygomatic breadth 25.6 (23.5–27.3); interorbital breadth 9.8 (9.0–10.8); mastoidal breadth 22.4 (21.4–24.0). Cranial measurements of three adult females from Laurel are: Basilar length 36.1, 36.4, 36.5; zygomatic breadth 21.5, 21.7, ——; interorbital breadth 7.9, 9.1, 9.1; mastoidal breadth 18.9, 19.0, 18.2.

Habitat and habits.—This weasel prefers bushy field borders, brushland, open woodland, and woodland bordering cultivated fields and pastures. It is quite adaptable and willing to live in close proximity to man as long as suitable prey is available. Recently, I found one dead on a road in the middle of Kensington, Montgomery County, where the only suitable habitat for some distance was the bushy area bordering a railroad track that runs through the center of town. Uhler and Llewellyn (1952, p. 81) report that during a study made at the Patuxent Research Center in Prince Georges County, only four weasels were taken in three trapping seasons. Of these, two were taken along hedgerows, one in upland forest, and one along the Patuxent River. In the Bare Hills–Lake Roland area, Bures (1948, p. 66) thought these weasels were quite rare at first. Subsequent investigation revealed, however, that they were more common than he suspected, and that they range throughout the area except for the marsh and Serpentine. He says that they seem to use the railroad right-of-way as a natural highway regularly; their mortality rate was high there, since an average of four specimens a year were recorded killed by passing trains. In an area as small as that in which Bures was working, this is a high number of weasels.

This species generally does not make its own burrow, but uses an abandoned one of a chipmunk or mole. Sometimes it will utilize a hole among rocks or under a stump. The nest center is usually filled with grass and lined with fur and feathers from the weasel's prey.

Mating in this species occurs in July and August. The gestation period is very prolonged, averaging about 279 days, but as in the ermine, the embryo remains quiescent throughout most of this period and only begins to develop rapidly during the last 27 days. The young, numbering between six and eight, are born from mid-April to mid-May. Hamilton (1933b, p. 328) states that the male stays with the female and assists in caring for the young. He says that he has several times seen a male of this species carrying food to a den of young ones.

Like the ermine, the long-tailed weasel is strictly carnivorous in diet. Hamilton (1933b, p. 333) lists the percentages of fall and winter food of this species in New York State as follows: Meadow mice 33.6; cottontail rabbits 17.3; white footed mice 11.3; rats 9.1; short-tailed shrews 5.9; squirrels 2.7; chipmunks 1.0; star-nosed moles 0.8; muskrat 0.8. In addition to this, a small percentage of birds and reptiles is consumed.

Specimens examined.—Allegany County: Piney Mountain, 2 (Coll. U. Md.). *Anne Arundel County:* Patuxent (2 miles S), 1. *Howard County: Hanover*, 1; Long Corner, 1. *Montgomery County:* Bethesda, 1; Chevy Chase, 1; Foxhall Village (D.C.? not located in Maryland), 1; Gaithersburg, 1; Garrett Park, 1; Kensington, 1; Linden, 1; Olney, 1; Plummers Island, 3. *Prince Georges County:* Andrews Air Force Base (near), 1; Bladensburg, 1; Branchville, 1; Laurel, 17; Oxen Hill, 1. *Talbot County:* Easton, 1. *District of Columbia:* 8.

Other records and reports.—Baltimore County: Bare Hills–Lake Roland area (Bures, 1948, p. 66); Halethorpe (Hampe, 1943, p. 66); Loch Raven (Seibert, 1939, p. 21); Patapsco State Park (Hampe, 1938, p. 6). *Calvert County:* Plum Point (identified from photograph submitted by John F. Fales). *Dorchester County:* Cambridge (five specimens in collection of R. W. Jackson, examined by Hall, 1951, p. 228). *Garrett County:* Grantsville (E A. Preble, in field notes, mentions seeing one, June 1899). *Montgomery County:* Sandy Spring (Bailey, 1923, p. 126).

(LEAST WEASEL)

Mustela nivalis allegheniensis (Rhoads)

Putorius allegheniensis Rhoads, Proc. Acad. Nat. Sci. Philadelphia, 52: 751, 25 March 1901.

Type locality.—Near Beallsville, Washington County, Pa.

General distribution.—From Wisconsin and northern Illinois eastward through northern Indiana, Michigan, and Ohio into southwestern New York and Pennsylvania, thence southward in the Appalachians to North Carolina.

Distribution in Maryland.—This species has not been recorded as yet from Maryland, but it has been taken in nearby Pennsylvania, West Virginia, and Virginia, and probably ranges through the Allegheny Mountain section of Maryland and possibly in the Ridge and Valley section as well.

Distinguishing characteristics.—A very small weasel, similar to both *M. frenata* and *M. erminea* in coloration and general form, but considerably smaller than either. It may readily be distinguished from both these species by its very short tail and the complete lack of a black tail tip.

Measurements.—"Male: An adult or subadult from Fair Oaks, Pa., a subadult from Finleyville, Pa., and an adult from Huttonsville, W. Va., measure respectively as follows: Total length, 206, 194, 191 (average 197); length of tail, 37, 32, 28 (32); length of hind foot, 23 in each.

"Female: Two young from Leasuresville, Pa., and Middle Paxton Twp., Pa., measure respectively, as follows: total length, 188, 172; length of tail, 33, 30; length of hind foot, 20.5, 21." (Hall, 1951, p. 187–188.)

Some of the cranial measurements listed by Hall (1951, p. 440–441) of an adult male from Huttonsville, W. Va., and an adult female from Beallsville, Pa., are Basilar length (of Hensel) 28.5, 28.0, zygomatic breadth 16.7, 14.6; interorbital breadth 7.1, 6.2; mastoidal breadth 15.1, 13.5.

Habitat and habits.—This species inhabits both the deep forests and the fields and pastures within its range. It is a rare mammal however, and is seldom encountered.

Little is known of its habits. Hamilton (1943, p. 139) says that nests have been found beneath corn shocks, in shallow burrows bordering streams, and in similar places. The few nests that have been discovered were composed of grasses and mouse fur. Hamilton states that the breeding habits of this species apparently differ from those of its larger relatives. He says that young with unopened eyes have been discovered in midwinter, while nest young and lactating females have been found in Pennsylvania during October, January, and February. These litters numbered from three to six young. The female parent was always in attendance. From this he says that the young are probably born at various seasons and there is a likelihood of more than one litter a year.

Hall (1951, p. 177) says that food of the least weasel consists of harvest mice, deer mice, meadow mice, red-backed mice, and possibly insects.

MINK

Mustela vison mink Peale and Palisot de Beauvois

Mustela mink Peale and Palisot de Beauvois. A scientific and descriptive catalogue of Peal's museum, Philadelphia, p. 39, 1796.

Type locality.—Maryland.

General distribution.—Eastern United States from southeastern Maine, south to coastal North Carolina, and inland (excepting the higher elevations of the Appalachians) through Pennsylvania, Michigan, Georgia, and Alabama to Missouri.

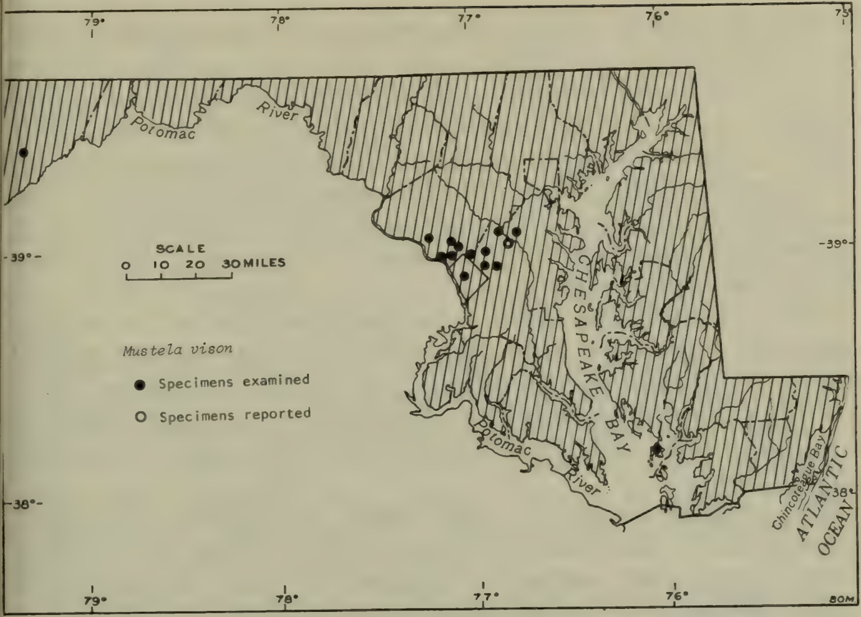

FIGURE 50.—Distribution of *Mustela vison.*

Distribution in Maryland.—The species is Statewide in distribution; the subspecies *mink* occurs throughout most of Maryland, but may be replaced by the race *vison* at higher elevations in the Allegheny Mountain section. This very dark northern race, *vison*, has been reported in the Appalachians to the south of Maryland (Kellogg, 1939, p. 262), but the only specimen available from the Allegheny Mountain section of Maryland is a zoo animal and its subspecific affinities are indeterminable.

Distinguishing characteristics.—A very large weasel, with a fairly long, bushy tail; coloration dark glossy brown over entire body, except for a whitish chin spot and an occasional white streak on the neck or white spot on the chest or belly; pelage thick and dense, adapted for an aquatic life.

The mink may distinguished from the long-tailed weasel by its larger size, and absence of a white belly. It is similar to an otter in coloration, but is smaller and does not have a broad-based tail.

Measurements.—Males considerably larger than females. A typical adult male and female from Montgomery County have the following external and cranial measurements: Total length 650, 547; tail 225, 193, hind foot 70, 54; basilar length 62.4, 56.0; zygomatic breadth 42.1, 36.3; interorbital breadth 12.9, 13.7; mastoidal breadth 34.4, 30.5.

Habitat and habits.—The mink always lives near water. It is found around lakes, in or near marshes, and along the banks of rivers or streams. It prefers forested, log-strewn, and bushy areas. At the Patuxent Wildlife Research Center near Laurel, Prince Georges County, Uhler and Llewellyn (1952, p. 84) found them along lake margins, by a small stream, and along the Patuxent River. Bailey (1923, p. 125) reported that in the early 1920's they were fairly common along the banks of almost any stream in Washington, D.C., and that they followed Rock Creek well down into the city. Today, owing to stream pollution and other factors few, if any, mink occur along Rock Creek in Washington.

Mink make their home under large trees which line banks of streams along which they live. They also inhabit muskrat lodges or natural cavities along the banks of streams, rivers, lakes, or marshes. Males and females build separate nests, but females build more elaborate ones, lining them with grass, feathers, and fur to make a snug home for the young.

The breeding season for mink begins in January and extends through March; the gestation period is variable, from 39 to 76 days, depending on when mating has occurred; the later the mating, the shorter the gestation period. Three to six young are born in April or May, but as many as 10 have been reported.

Mink range over a wide area to procure their food, which consists of any reptiles, amphibians, small mammals, and birds obtainable. In areas where muskrat abound, such as the muskrat marshes of the Delmarva Peninsula, mink may feed extensively on them. Llewellyn and Uhler (1952, p. 199), in studies conducted at the Patuxent Research Center, report that it is usually difficult to get food-habits material from trapped mink since their digestion is so rapid. They state that frequently stomachs of the animals studied were empty, and only digested blood was found in the intestines. They were only able to obtain six stomachs and four scats suitable for tabulation. In none of these was there any plant food except for a few poison-ivy seeds which were found in a stomach that contained flicker remains. Presumably the bird had eaten these seeds before being captured by the mink. One mink sample in March and another in December contained rabbit hair only. Five other winter samples had 100 percent rodent remains consisting of one meadow mouse, three pine mice, and one "wood" mouse. In the two additional stomachs examined by Llewellyn and Uhler, one contained flicker remains and the other had a beetle fragment.

The mink sometimes does considerable damage to poultry. Bailey (1923, p. 125) says that he was told of a mink in the Washington area that visited a henhouse and killed 22 chickens in one night and returned the next night to kill 16 more. The following night, as the mink was returning to the henhouse again, it was caught by a dog.

Despite the great number being bred in captivity, wild-caught mink re still in some demand for their fur, and each year many are trapped hroughout the country. Maryland does not rank high in wild mink roduction. In 1966, only 303 mink were reported trapped in the State U.S. Fish and Wildlife Service, Fur Catch in the United States, 1966, Wildlife Leaflet 478). The high point in mink trapping in Maryland ver the past decade was reached during the 1950–51 season when ,370 animals were taken (U.S. Fish and Wildlife Service, Fur Catch in the United States, 1949–54, Wildlife Leaflet 367) for their elage.

Specimens examined.—Anne Arundel County: Little Patuxent River, 1. *Dorchester County:* Bloodsworth Island, 1. *Garrett County:* Oakland (through National Zoological Park), 1. *Montgomery County:* Bethesda, 1; Cabin John, 2; Forest Glen, 2; Garrett Park, 1; Potomac, ; Sligo Creek (near Takoma Park), 1; no exact locality, 2. *Prince Georges County:* Bladensburg, 1; Branchville, 2; College Park, 1; Lanham, 1; Laurel, 44; no exact locality, 1.

Other records and reports.—Montgomery County: Plummers Island (Goldman and Jackson, 1939: 132). *Prince Georges County:* College Station, 8 miles NE of Washington; Patuxent Research Center. Uhler and Llewellyn, 1952, p. 84).

STRIPED SKUNK

Mephitis mephitis nigra (Peale and Palisot de Beauvois)

Viverra nigra Peale and Palisot de Beauvois, A scientific and descriptive catalogue of Peale's museum, Philadelphia, p. 37, 1796.

Type locality.—Maryland.

General distribution.—New England and southern Ontario south to Virginia, and west of the Allegheny Mountains from the lower peninsula of Michigan and southern Illinois south to central Mississippi, Alabama, and Georgia.

Distribution in Maryland.—Distributed throughout the State, but most abundant in the Allegheny Mountain, Ridge and Valley, and Piedmont sections; scarce or lacking in many areas of the Eastern Shore section. According to the Service Survey (U.S. Fish and Wildlife Service, vol. 3(4), p. 15, December 1943), with the breaking up of the former dense forest cover the striped skunk seems to be slowly making its way southward along the Delmarva Peninsula into Dorchester County from Talbot County.

Distinguishing characteristics.—Teeth 3/3, 1/1, 3/3, 1/2, = 34; size large; body heavy, particularly rearward; tail very thick and bushy; legs short; pelage dense and coarse; coloration black with a thin white stripe medially on the nose, and two white stripes running from head to tail. The amount of white on the striped skunk is subject

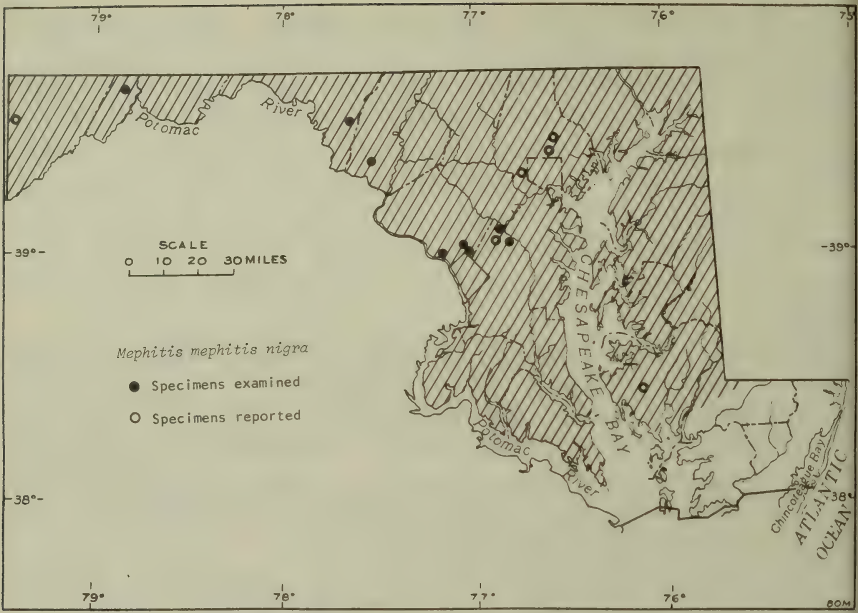

FIGURE 51.—Distribution of *Mephitis mephitis nigra.*

to considerable individual variation. Some animals are almost completely black, while others are predominately white on the back.

This species cannot be confused with any other Maryland mammal except possibly the spotted skunk (*Spilogale*), from which it differs in larger size and in having two rather than four white dorsal stripes. In *Mephitis* the nose patch is always a slender stripe, whereas in *Spilogale* it is a broad triangular patch.

Measurements.—Two adult males and two adult females from Cabin John, Montgomery County, have the following external and cranial measurements: Total length 597, 648, 568, 648; tail 228, 260, 235, 270; hind foot 64, 70, 57, 67; basilar length of skull 61.5, 60.5, 55.0, 60.0; zygomatic breadth 43.2, 46.7, 41.4, 41.9; least interorbital breadth 18.8, 19.6, 19.2, 18.1; maxillary toothrow 21.3, 20.7, 20.2, 20.5.

Habitat and habits.—This skunk is found in brushland, sparse woods weedy fields or pastures, under wood piles and rock piles, and around buildings. It is most common along brushy borders of streams and in rock piles and thickets at the base of cliffs.

The striped skunk makes its home in a burrow which it may dig in a brushy area or pasture, or it may occupy the burrow of some other animal such as a woodchuck. Occasionally the den may be in a cave or under a log or stump. Burrows average between 18 and 20 feet long and may reach to a depth of 3 to 4 feet below the surface of the ground.

The nest within the burrow is a somewhat wider area lined with dry leaves and grass.

The striped skunk is polygamous, and mating occurs from February until March, with the young being born in May or June. Only one litter is produced annually, and between two and 10 (usually six or seven) kits comprise a litter. The gestation period is 60 to 62 days.

Llewellyn and Uhler (1952, p. 200) studied the food habits of skunks at the Patuxent Wildlife Research Center, Prince Georges County. The results of their examination of 63 digestive tracts and 33 scats mostly taken in fall and winter are summarized as follows:

Plant material comprised some 10 percent of the food intake. The only plant item found regularly in the stomach was persimmon, which accounted for about 7 percent. Also occasionally found were beechnuts, acorns, corn, wheat, pokeberry, blackgum, smilax, and a few other fruits and berries; some of this plant material was apparently garbage. Animal matter comprised between 80 percent and 90 percent of the food intake; insects formed almost half of the total and were most prominent in the fall. About 20 percent of the insects consumed consisted of beetles, with scarabs such as June beetles (mostly larvae) and Japanese beetles (mostly adults) leading the list. Ground beetles were also found frequently. The next highest group (11 percent) was made up of grasshoppers and crickets. A large number (5 percent) of true bugs, chiefly stink bugs, were eaten. In later summer and fall, it was evident that in several instances the skunks had dug out yellow-jacket nests and eaten the occupants. Lamore (1953, p. 80) reports that he found a striped skunk dead on the highway near Beltsville, Prince Georges County, in August 1962. The animal's stomach was filled with yellow jackets.

Rodents, chiefly wood mice, meadow mice, and squirrels, comprised 15 percent of the diet; eight occurrences of rabbit totaled 5 percent. Llewellyn and Uhler (1952, p. 200) believe that the squirrels and rabbits were probably road kills, carrion, or hunting cripples, although remains of rabbits that could have been nestlings were found in two scats. Birds were found in 14 stomachs or scats and made up 7 percent of the volume. One box turtle, one king snake, and several undetermined snakes and salamanders were also found. Millipedes were found frequently in fall and winter and often made up entire meals. Spiders also appeared often, and centipedes occasionally, but their remains consisted mostly of legs, so that their volume constituted a small percentage of the total.

This skunk, like its spotted relative, possesses a powerful scent as a defense mechanism. The fluid which contains the scent can be ejected for a considerable distance, and if it should strike one's eye it will cause burning and smarting. Burning can be relieved by washing the eye in lukewarm water, followed by flushing with boric acid. Turpentine is useful for removing skunk odor from clothing and from skin, and tomato juice is also effective.

Skunk fur is commercially valuable, and in the 1965–66 trapping season, 161 striped skunks were reported taken in Maryland by fur trappers (U.S. Fish and Wildlife Service, Fur Catch in the United States, 1966, Wildlife Leaflet 478).

Specimens examined.—Allegany County: Mount Savage, 1 (Coll. U. Md.). *Frederick County:* Jefferson, 1. *Montgomery County:* Cabin John, 4; Forest Glen, 1; Silver Spring, 1. *Prince Georges County:* Laurel, 6; Patuxent Research Center, 2. *Washington County:* Boonesboro, 1.

Other records and reports.—Baltimore County: Bare Hills–Lake Roland area (Bures, 1948, p. 66); Loch Raven (Kolb, 1938); Patapsco State Park (Hampe, 1939, p. 6). *Dorchester County:* Blackwater National Wildlife Refuge (Service Survey, U.S. Fish and Wildlife Service, 3(4), p. 15, December 1943). *Garrett County:* Cranesville Pine Swamp (Mansueti, 1958, p. 83). *Montgomery County:* Plummers Island (Goldman and Jackson, 1939, p. 132). *Prince Georges County:* Beltsville, near (Lamore, 1953, p. 80).

EASTERN SPOTTED SKUNK

Spilogale putorius putorius (Linnaeus)

[*Viverra*] *putorius* Linnaeus, Syst. nat., ed. 10, 1:44, 1758.

Type locality.—South Carolina.

General distribution.—"Southeastern United States from Alabama, Mississippi, and northern Florida northward through western and central Georgia and South Carolina and northward in the Appalachian Mountains to south-central Pennsylvania." (Van Gelder, 1959, p. 225).

Distribution in Maryland.—Ridge and Valley and Allegheny Mountain sections.

Distinguishing characteristics.—Teeth 3/3, 1/1, 3/3, 1/2, = 34; size small; coloration striking, the background being black, striped with four white dorsal stripes which run about to the middle of the back, the center ones being somewhat narrower than the outer; stripes breaking up into patches on the hind quarters, giving the skunk a spotted appearance; broad triangular white patch on nose and forehead; small white patch in front of ears; tail long and full, broadly tipped with white.

This skunk is readily distinguished from the striped skunk (*Mephitis mephitis*) by the patterning of its coloration. *Spilogale* has four white stripes on the body whereas *Mephitis* has two (these may be highly variable, however, in length and breadth). *Spilogale* has a

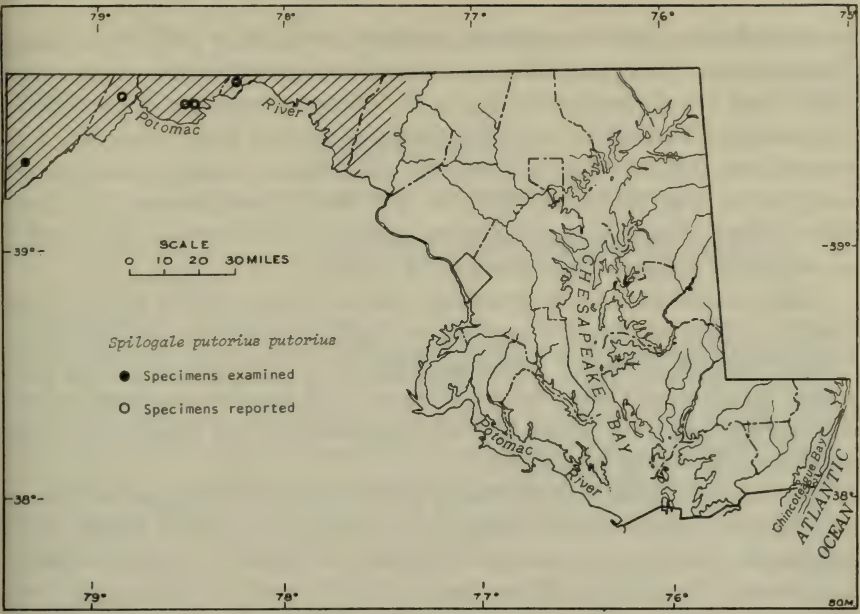

FIGURE 52.—Distribution of *Spilogale putorius putorius*.

broad triangular white nose patch, while *Mephitis* has only a thin white stripe medially on the nose. The spotted skunk is considerably the smaller species.

Measurements.—Van Gelder (1959, p. 255) gives external and some cranial measurements of this subspecies as follows: Males: Total length 506.6 (453–610); tail 180.9 (152–211); hind foot 47.8 (41–51); condylobasal length of skull 57.2 (53.6–61.9); zygomatic breadth 35.3 (32.5–37.8); interorbital breadth 15.5 (13.5–16.9); length of maxillary toothrow 18.4 (17.0–20.5). Females: Total length 450.7 (403–470); tail 171.9 (154–193); hind foot 44.0 (39–47); basilar length of skull 47.6 (45.0–50.0); zygomatic breadth 33.2 (31.8–34.8); interorbital breath 15.0 (13.5–15.9); length of maxillary toothrow 17.7 (16.6–18.6).

A male from Piney Mountain, one-quarter mile north of U.S. Route 40 at Clarysville, Allegany County, has the following external and cranial measurements: Total length 425; tail 155; hind foot 45; ear 13; condylobasal length of skull 55.1; zygomatic breadth 34.1; interorbital breadth 14.8; length of maxillary toothrow 17.7.

Habitat and habits.—In the northern part of its range this species prefers to live in rock piles and crevices in cliffs. In more southern areas of the southeastern United States it often inhabits wasteland and cultivated fields and sometimes build its nest under farm buildings or lives in deserted woodchuck burrows. All of the areas in which spotted skunks have been taken or observed in Maryland are similar. They are at or near the summits of mountains at altitudes above 1,600 feet. They are characterized by rocky outcrops which run parallel to the summits and which may be several hundred feet in length. The vegetation consists of second-growth oaks (*Quercus* spp.) and hickories (*Carya* spp.), with black locust (*Robinia pseudocacia*), Virginia pine (*Pinus virginiana*), and dense tangles of wild grape (*Vitis* spp.) occasionally present (Bookhout, 1964, p. 214).

Little is known of the breeding habits of the spotted skunk. Van Gelder (1959, p. 260–270) says that there is evidence that this subspecies has an extended breeding period, or that two litters a year might be produced since there are records of females nursing in both the spring and fall. There are between two and six young, with the usual number being four or five.

According to Hamilton (1943, p. 159) the food of this species during the winter months consists largely of rabbits, mice, and other small mammals; during the summer and fall it fattens on fruits, insects, and birds. Lizards, small snakes, and offal are not disdained, and the spotted skunk will steal eggs and kill chicks. It is fond of persimmons and various other fruits in season.

This skunk possesses a means of defense consisting of a characteristic evil-smelling fluid which is secreted by two anal glands. This fluid, or musk as it is sometimes called, can be ejected accurately up to several feet in the direction of attackers. It is more overpowering, blinding, and burning than that of *Mephitis*, and there are few animals that are not repulsed by it.

Specimens examined.—Allegany County: Piney Mountain, ¼ mile N of U.S. Route 40, at Clarysville, 1 (specimen taken 10 February 1964). *Garrett County:* Locklynn Heights, 1 (specimen taken in mid-January 1963).

Other records and reports.—Latham and Studholme (1947, p. 409) report a specimen from 4 miles west of Hancock, Washington County. James H. Beal, of Frostburg, tells me (in correspondence) that he collected a specimen on Town Hill (Mountain), Allegany County, near the beacon light in August 1962, and another near the same locality in 1959. The following records are from Bookhout (1964, p. 214) : Green Ridge Mountain (elevation 1,400 ft.), Allegany County (one animal seen in December 1957) ; and Dan's Mountain (elevation 1,600 ft.), Allegany County (four specimens trapped since 1960).

Remarks.—The spotted skunk is essentially a southern species and has apparently extended its range into Maryland and Pennsylvania only within recent years. The first record of a spotted skunk in Pennsylvania was as recent as 40 years ago (Latham and Studholme, 1947,

p. 409) despite the fact that trappers, hunters, and collectors have been working in the Maryland and Pennsylvania mountains since Colonial times.

RIVER OTTER

Lutra canadensis lataxina F. Cuvier

Lutra lataxina F. Cuvier, *in* Dictionnaire des sciences naturelle . . . 27: 242, 1823.

Type locality.—South Carolina.

General distribution.—Coastal Plain and Piedmont of the eastern United States, from western Connecticut and southern New York, south to South Carolina.

Distribution in Maryland.—The species is statewide in distribution. The subspecies *lataxina* inhabits the Eastern Shore, Western Shore, and Piedmont sections, but may be replaced by *Lutra canadensis canadensis* in the Ridge and Valley and Allegheny Mountain sections where it is scarce or possibly absent (Bookhout, in correspondence). No specimens are available to establish the subspecific identity of the western Maryland otters (if they occur there), but since *L. c. canadensis* has been reported from the mountains of Virginia to the south (Handley and Patton, 1947, p. 133) and West Virginia to the west (Kellogg, 1937, p. 453), western Maryland specimens, if and when obtained, probably will prove referable to *L. c. canadensis*.

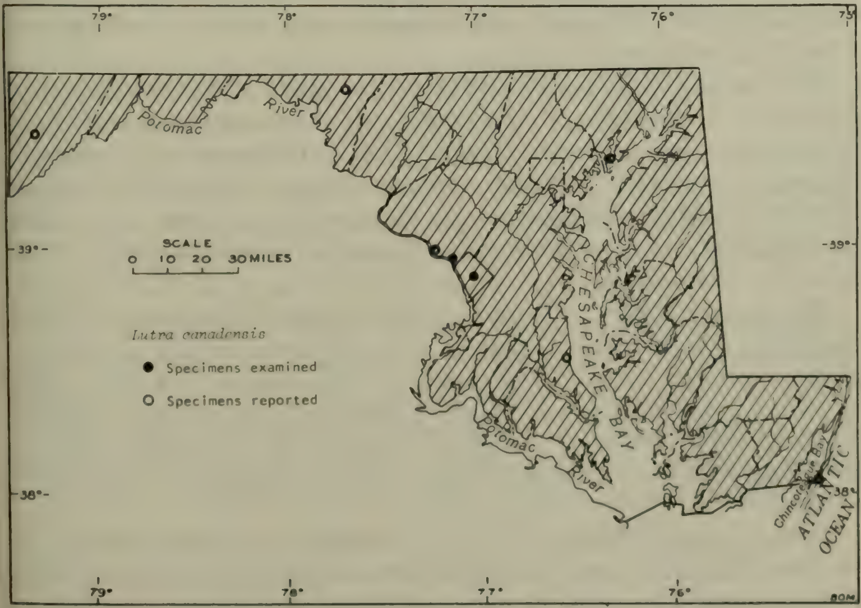

FIGURE 53.—Distribution of *Lutra canadensis*.

Distinguishing characteristics.—Teeth 3/3, 1/1, 4/3, 1/2, = 36; size large; body slender and elongated; head small, broad, and flattened; ears and eyes small and rounded; nose broad and flat; tail long, about a third of the total length of the animal, very heavy at the base and tapering toward the tip; legs very short, ending in large feet with webbed toes; pelage consisting of a dense underfur overlaid with silky guard hairs; coloration a rich deep brown, generally somewhat paler on the belly and often with a grayish mixture on the lips, chin, and throat. The subspecies *L. c. canadensis* is similar to the above but considerably darker in coloration.

The combination of large size, flat, broad head, thick, heavy tail, and webbed toes distinguish the otter from similar mammals in Maryland.

Measurements.—No external measurements are available for the Maryland and District of Columbia specimens in the National collections. Handley and Patton (1947, p. 134) give the range of external measurements in otters as follows: Total length 900–1,200; tail 300–400; hind foot 100–120.

A young male from Glen Echo, Montgomery County, and an unsexed (but apparently a male) old adult from Washington, D.C., have the following cranial measurements: Basilar length 95.8, 101.6; zygomatic breadth 65.3, ——; postorbital breadth 19.1, 20.7; mastoidal breadth 62.9, 66.7; length of maxillary toothrow 35.2, 38.8. Two unsexed (but apparently female) adults from Washington, D.C., measure cranially: Basilar length 87.5, 90.6; zygomatic breadth 64.3, ——; postorbital breadth 17.2, 19.2; mastoidal breadth 56.7, 59.9; length of maxillary toothrow 32.9, 34.2.

Habitat and habits.—The otter occurs along rivers, streams, and lakes, and it appears to be quite common in the marshes that border the Chesapeake Bay and the Atlantic Ocean. It occurs on Assateague Island, where Jacob Valentine, former manager of the Chincoteague National Wildlife Refuge, told me that as many as seven were living in 1958. Most of these, however, were in the Virginia portion of the island, on the Refuge.

Maryland's Eastern Shore supports a large population of otter. Audubon and Bachman (1851, p. 11) and Coues (1877, p. 211) reported them as common there in the 19th century. Brayton (1882, p. 58) says that the Eastern Shore of Maryland appears to have always been a favorite resort of the otter. Another area where this species is abundant is on the Proving Grounds near Edgewood Arsenal, Harford County.

Otters were at one time relatively common along the Potomac River and its tributaries in the vicinity of Washington, D.C., and have often been reported from the city proper. Bailey (1923, p. 125) records an otter at the north end of Rock Creek Park in 1920 and one taken at

Eastern Branch near Bennings in 1895. In nearby Maryland he reports that otter tracks were seen on Plummers Island in 1910 and 1922, and that one was observed swimming across the Potomac River near Seneca in April 1920. Otters still are not uncommon along the Potomac River both to the north and south of Washington. L. G. Henbest observed one swimming in the Potomac near Great Falls in late January and February 1964 and obtained a photograph of the animal when it climbed out onto a rock on the Maryland side of the river.

The otter may be active any time of the day or night, but tends to be more nocturnal than diurnal. Even though it may be common, it is seldom seen by the casual observer because it is shy and spends much of its time in water. These animals are powerful and graceful swimmers and dive with ease and agility. When swimming on the surface it holds its head high out of the water and both the forelegs and hind limbs are directed backward, progression being made primarily by twisting and moving the body and tail. The otter can reach a speed of 6 or 7 miles an hour on the surface, and nearly as great a speed when submerged.

The otter inhabits a well hidden den along the bank of the stream or river in which it lives. According to Liers (1951, p. 4) these animals seldom dig their own dens, but utilize abandoned beaver lodges or wood-chuck or muskrat burrows, enlarging them to suit their needs. Often these dens are simply short tunnels, but sometimes they may be extensive and complicated. The main entrance is always under water. In marshes, the otter may prepare a nest from dry marsh grasses.

Nothing has been published concerning the breeding habits of otters in Maryland. Liers (1951, p. 4) studied them in Minnesota under semiwild conditions and reports that otters breed there in winter and early spring. He found the gestation period to vary from 9 months 18 days to 12 months 15 days. Only one litter is produced a year, comprising generally two to four young. The male is allowed to rejoin the family group after the young have left the nest, and he assists the female in teaching them to swim and hunt for food.

The otter eats a variety of foods, but is primarily carnivorous, consuming crayfish, frogs, turtles, larvae of aquatic insects, angleworms, and fish (Liers, 1951, p. 1). Jackson (1961, p. 388) says that the otter rarely eats muskrat, young beaver, or duck, and that the parts of land vertebrates occasionally found among its remains probably were eaten as carrion. On Assateague Island the otters appeared to be feeding largely on jumping mullet (*Mugil cephalus*).

Otter fur is currently commanding good prices on the market, being durable, soft, and dense. During the 1965–66 trapping season, 495 wild otters were trapped in Maryland for the fur market (U.S. Fish and

Wildlife Service, Fur Catch in the United States, 1966, Wildlife Leaflet 478).

Specimens examined.—Montgomery County: Glen Echo, 1. *District of Columbia*: 3.

Other records and reports.—Calvert County: Chesapeake Bay, near Stoakley (LeCompte, 1937: 15). *Garrett County*: Deep Creek Lake (Browning, 1928, p. 213). *Harford County*: Edgewood Arsenal area (personal observation). *Montgomery County*: Great Falls (identified from photograph taken by L. G. Henbest, February 1964). *Washington County*: near Leitersburg (Washington, D.C., Herald, 7 January 1909). *Worcester County*: Assateague Island (personal observation).

Family FELIDAE (cats)

BOBCAT

Lynx rufus rufus (Schreber)

Felis rufa Schreber, Die Säugthiere . . . , Thiel 3, Heft 95, pl. 109b, 1777.

Type locality.—New York.

General distribution.—In the eastern United States, this race formerly occurred from central New England south to northern Georgia, and west into the Dakotas, Iowa, Kansas, and Oklahoma. It is now absent or rare in the Coastal Plain in the southern portion of its range except in Virginia's Dismal Swamp.

Distribution in Maryland.—Formerly statewide in distribution, but now confined primarily to the Allegheny Mountain and Ridge and Valley sections. It has been entirely exterminated in the Eastern Shore section and is only rarely encountered in the Western Shore and Piedmont sections.

This species is uncommon enough in Maryland to produce local newspaper accounts when one is taken.

Distinguishing characteristics.—Teeth 3/3, 1/1, 2/2, 1/1, = 28; general appearance catlike, but considerably larger than a domestic cat, averaging about twice as much in size and weight; body short; ears prominent and with small conspicuous tufts on the tips; eyes large and with eliptical pupils; tail very short, less than a fourth of the total length of the animal; pelage fairly long and loose; coloration of upperparts grayish to brownish, darker along the midline, and spotted and blotched throughout; abdomen and inner sides of legs white, prominently marked with black spots; tail always tipped with black.

The only Maryland mammal with which the bobcat may be confused is the domestic cat, from which it is readily distinguished by its larger size and short black-tipped tail.

Measurements.—No external measurements are available for Maryland or District of Columbia specimens in the National collections.

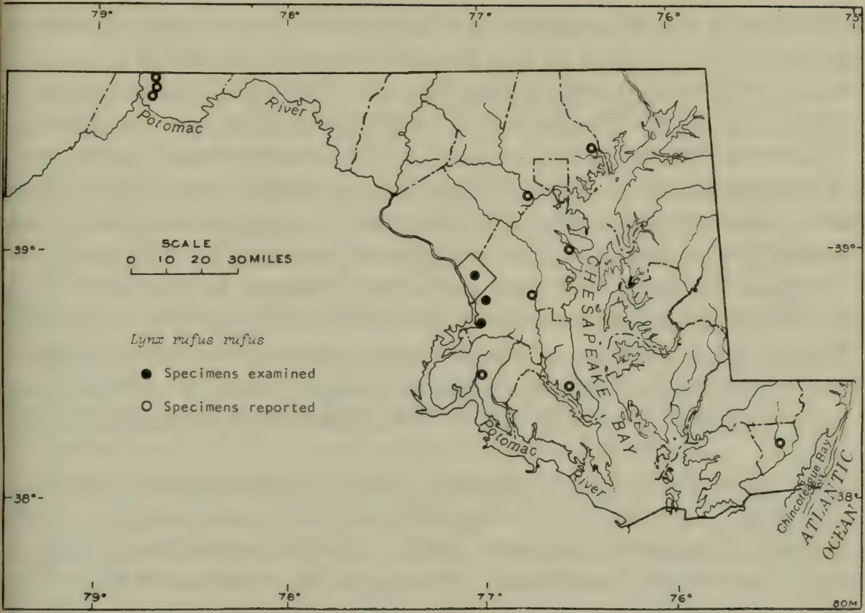

FIGURE 54.—Distribution of *Lynx rufus rufus.*

Kellogg (1937, p. 457) gives external measurements of 11 adult males from West Virginia as follows: Total length 870 (787–935); tail 146 (133–165); hind foot 171 (162–195). According to Jackson (1961, p. 402) the male bobcat averages about 10 percent longer than the female and weighs about 30 percent more.

A female from near Fort Washington, Prince Georges County, has the following cranial measurements: Greatest length 128.0; zygomatic breadth 83.7; interorbital breadth 23.2; maxillary toothrow 40.4.

Habitat and habits.—Bobcats prefer wild heavily wooded or brushy areas, particularly in rocky habitats and swamps. In Maryland the animal is still fairly numerous in the wilder areas of the Allegheny Mountain and Ridge and Valley sections, but is very scarce in the rest of the State. No specimens have been taken in the Eastern Shore section for many years, and presumably the animal is extirpated there. According to Mansueti (1950, p. 21) the species has been ruthlessly exterminated in Maryland as "vermin," and is everywhere much scarcer than in the past.

Mansueti (1950, pp. 22–23) has gathered together a number of bobcat records in Maryland. He says that Meshach Browning is reported to have killed scores of bobcats in the early 19th century, and that they were an everyday occurrence in Garrett County then. Marye (1945) says that a generation ago bobcats were destructive to sheep near the Falls of the Patapasco River, and that in his time they were occasionally killed in Baltimore County. He reports that in the 1920's he saw a large bobcat in Day's woods, between the Great and Little Falls of the Gunpowder River. He also cites some notes relative to the bobcat on the Eastern Shore and says that about 2 decades ago (also in the 1920's), a wild animal of the cat family was treed by dogs on the borders of the Nassawango Swamp, near Nassawango Bridge in Worcester County. The animal escaped and Marye doubts that any domestic cat could have done so under the circumstances imposed.

Mansueti (1950, p. 22) quotes an article from the Baltimore Evening Sun (18 February 1948) entitled "Bobcats Still Here," which says that Thomas Leary, hunter of Beans Cover, Allegany County, trapped a bobcat in 1948 on Evitts Mountain in Allegany County and the newspaper published a photograph of the animal, thus substantiating the capture.

Mansueti (1950, p. 23) says that John Hamlet, formerly with the U.S. Fish and Wildlife Service, told him that a few years ago (1945 or 1946) a bobcat was known to be roaming the Cypress Swamp region of Calvert County, and Watson Perrygo of the Division of Mammals, U.S. National Museum, tells me that bobcats are presently residing in wild areas on his property near Port Tobacco in Charles County.

Several interesting specimens of bobcats from Maryland and the District of Columbia are in the collections of the U.S. National Museum. One of these, a young female, was shot along with five others in a swamp near Oxon Hill, Prince Georges County, in 1941 when the swamp was being razed for a housing development. Another (an old female) was found dead in December 1958 on the curb of a downtown Washington Street, not far from Rock Creek Park. The animal was not examined for bullet wounds but probably was shot in the mountains west of Washington and then dumped from an auto onto the Washington Street, although it is remotely possible that it had wandered naturally into downtown Washington via Rock Creek Park. Bailey (1923, p. 121) lists several bobcat records from nearby Virginia.

The Maryland Conservationist (27(1), pp. 9, 28, Spring 1950) records the capture of a particularly large bobcat in Maryland. On Labor Day of 1949, Frank Wigfield killed the animal on Iron Mountain, about 5 miles east of Cumberland, Allegany County. It weighed 43 pounds and measured 53 inches from tip to tip.

The bobcat is shy and retiring, and primarily solitary in its habits. It is almost entirely nocturnal and is seldom abroad in daylight. Generally, it seeks shelter under shrubs or in rock crevices, but sometimes it dens in hollows trees, stumps, or logs. The den is lined with grasses, leaves, moss, and other vegetation, which are scraped and scratched into a nest.

Mating in this species occurs in February or March; the gestation period is about 50 days, and between one and four kittens are born, usually in April. At birth the young are blind; the eyes open after about 9 or 10 days. Although weaned when 60 to 70 days old, the young continue with the mother until autumn or sometimes late winter.

The food of the bobcat is entirely animal in nature, and consists to a large extent of rabbits as well as squirrels, mice, muskrats, and various kinds of birds. Bobcats often feed on deer; fawns are especially vulnerable prey, and no doubt deer carrion is often consumed. Domestic livestock, mainly calves and sheep but also occasionally poultry, are also eaten.

Mansueti (1950, p. 23) says that the bobcat is undoubtedly vanishing in Maryland, but its wary and secretive habits will insure its permanence in some of the more isolated portions of the State.

Specimens examined.—Prince Georges County: Fort Washington, near, 1; Oxon Hill, 1. *District of Columbia:* 1.

Other records and reports.—Anne Arundel County: Annapolis, 3 miles NW near Severn River (John C. Lingebach, in verbis). *Allegany County:* Evitts Mountain (Mansueti, 1950: 22); Iron Mountain (Md. Conservationist, 27(1), pp. 9, 28, Spring 1950). *Baltimore County:* Day's Woods between the Great and Little Falls of the Gunpowder River (Mansueti, 1950, p. 22). *Calvert County:* Cypress Swamp along Battle Creek (Mansueti, 1950, p. 23). *Charles County:* near Port Tobacco (W. M. Perrygo, in verbis). *Howard County:* Falls of the Patapsco River (Mansueti, 1950, p. 22). *Prince Georges County:* Patuxent River, near Upper Marlboro (Bailey, 1923, p. 121). *Worcester County:* Nassawango Swamp, near Nassawango Bridge (Mansueti, 1950, p. 22).

Order ARTIODACTYLA (even-toed hoofed mammals)

Family CERVIDAE (deer)

SIKA DEER

Cervus nippon Temminck

Cervus nippon Temminck, Coup d'oeil sur la faune des iles de la Sonde et de l'empire du Japon, xxii, 1838.

Type locality.—Japan.

General distribution.—Native to Japan, eastern China, Korea, and Manchuria. Introduced into England, New Zealand, Denmark, France, Austria, Russia, and the United States.

Distribution in Maryland.—James Island, Taylors Island, and adjacent mainland in Dorchester County, and Assateague Island Worcester County.

Distinguishing characteristics.—Teeth 0/3, 1/1, 3/3, 3/3, = 34; size small; coloration brownish olive or reddish olive with the middorsal area somewhat darker and forming an indistinct dark line from the forehead to the rump; underparts somewhat lighter; dorsum, particularly posteriorly, faintly speckled with indistinct white blotches in both young and adults, the white blotches being more noticeable in summer than winter; prominent white rump patch with semierectile hairs; antlers in male narrow, seldom having over three points and standing erect over head.

This species is distinguishable from the white-tailed deer by a number of easily recognizable characters. It is considerably smaller, averaging a third less in weight; has speckled pelage in young and old of both sexes; has narrower antlers that stand erect above the head, rather than curving forward over head; and possesses a small canine tooth in both sides of upper jaw.

Measurements.—No external measurements are available for any of the Maryland specimens. The species ranges in shoulder height from 32 to 43 inches (Tate, 1947, pp. 341–342).

Cranial measurements of an adult male from James Island, Dorchester County, are: Greatest length 231; zygomatic breadth 97.1; interorbital breadth 69.3; maxillary toothrow 68.6. Cranial measurements for two adult females from James Island are as follows: Greatest length 220, 224, zygomatic breadth 91.3, 93.4; interorbital breadth 53.0, 60.0; maxillary toothrow 62.5, 65.9.

Habitat and habits.—In its natural range, this species prefers hilly regions with mixed large-leafed forests. It does best in areas which are not subject to heavy snowfall (Flerov, 1952, p. 128).

In Maryland, it has been introduced on Assateague Island, and on James Island, from which it has spread to neighboring Taylors Island and the adjacent Dorchester County mainland. According to Flyger (1960a), four or five sika deer were released on James Island about 1916 by Clemment Henry, who had kept them in an enclosure near Cambridge for an unknown period before releasing them on the island. They multiplied on James Island and spread to nearby Taylors Island, and eventually to the mainland. Flyger and Warren (1958) estimated that in the fall of 1957, 270 sika deer inhabited James Island. Regarding their introduction to Assateague Island, Flyger (1960a) says that Charles Law of Berlin, Md., stated that he purchased five sika deer (two males and three females) from a man in Cambridge in 1920. These deer were held in an enclosure near Berlin for several years, during which time three young were born and one of the original males died. Dr. Law sold these deer to a man who in turn released them on Assateague Island where they have prospered and grown into a herd of over a thousand animals (Flyger, 1964, p. 213). Most of these, however, are located in the southern portion of the island in Virginia.

Sika deer can be hunted in Maryland during the regular deer hunting season, and nearly every year a few have been taken in Dorchester County. However, these deer are wilder and more timid than native white-tailed deer, and are more difficult to stalk. Because they are primarily nocturnal in habits many local people are even unaware of their existence in their neighborhood.

The sika deer has been introduced into various European countries, some of which are not pleased with the species since it is too secretive and wild to be a satisfactory game animal, and has a propensity for peeling bark from trees and competing with other species of deer for food (Flyger, 1959, p. 24). Whether it is a potential boon or threat to sportsmen in Maryland is still uncertain.

Little is known of the biology of this species in Maryland. In the Soviet Union where the animal has been widely introduced, Flerov (1952, pp. 128–129) reports that they are gregarious and that during certain periods their herds consist of many dozens of animals. Rutting begins in September and lasts for 1½ to 2 months. Rutting takes a very stormy course and is accompanied by roaring and terrific battles. After the rut, the males gather together in herds and remain apart from the females during the entire winter. Females with 2- or 3-year-old young also gather in separate groups just prior to winter. Calving occurs toward the end of May or June, generally one fawn, but occasionally twins, being produced.

These deer swim readily and sometimes will cross large bodies of salt water. Their food in Maryland is probably similar to that of the white-tailed deer, and it is feared that in areas where the sika deer becomes well established the native white-tailed species will not be able to compete for the available food supply.

Specimens examined.—Dorchester County: James Island, 8.

Remarks.—Presnall (1958, pp. 48–49) listed sika deer as occurring on Assateague Island, but incorrectly identified the deer from Dorchester County as hog deer (*Axis porcinus*). As pointed out by Flyger (1960a), not only are the Dorchester County animals *Cervus nippon*, but very probably they derive from the same stock as the Assateague Island populations.

In addition to Sika deer, Maryland supports small populations of introduced fallow deer (*Dama dama*). Presnall (1958, p. 48) says that a few animals remain from introductions in Worcester County (Mills Island in Chincoteague Bay) between 1920 and 1930, and in Talbot County between 1935 and 1945. Fallow deer are native to the Mediterranean region of southern Europe and western Asia, but have been widely introduced in northern Europe and the United States, where colonies exist in Kentucky, Tennessee, Virginia, and elsewhere. This deer is about the size of a Maryland white-tailed deer, but with large palmate antlers which are directed upward. In summer pelage, the coloration is fawn, with numerous white spots; in winter, a uniform grayish (although melanism and albinism are not infrequent). Miller (1912, pp. 971–972) gives external measurements of a European adult male of this species as: Head and body length 1540; tail 190; hind foot (with hoof) 435; ear from crown 165.

WHITE-TAILED DEER

Odocoileus virginianus borealis Miller

Odocoileus americanus borealis Miller, Bull. New York State Mus. Nat. Hist., 8: 83, 21 November 1900.

Type locality.—Bucksport, Hancock County, Maine.

General distribution.—"Western Ontario, east across southern Quebec, New Brunswick, and Nova Scotia; and from near James Bay (Newport, Abitibi River), Gaspé Peninsula, and Anticosti Island south to southern Maryland, southern Pennsylvania, Ohio, Indiana, and Illinois. Southern boundaries fixed at Potomac and Ohio rivers and the western limits at the Mississippi and Red Rivers." (Kellogg, 1956, p. 40).

Distribution in Maryland.—At one time the white-tailed deer was nearly extirpated in Maryland. Today it is common in all sections of the State, and is found in the wilder areas of every county.

Distinguishing characteristics.—Size large, larger than sika deer; antlers heavy, and main beam directed forward, bearing the several tines behind; upper parts of body colored reddish brown in summer and grayish in winter, unspotted except in juveniles; underparts and underside of tail white; juvenile animals are reddish yellow and spotted with white.

Measurement.—Kellogg (1956, p. 40) gives external measurements of the largest male of this subspecies that he examined as: Total length 2400; tail 365; hind foot 538; height at shoulder 1041. Two adult males from Cumberland, Allegany County, have the following cranial measurements: Condylobasal length ——, 261.8; width of orbit at frontojugal suture 129.7, 120.9; least interorbital breadth 74.2; length of maxillary toothrow 71.8, 72.5. Females average smaller than males in size.

Flyger (1958, p. 8) says that the average weight of 47 adult male deer from western Maryland was 127.5 pounds, and 17 from Worcester County averaged 125.4 pounds, whereas 6 from the Aberdeen Proving Grounds in Harford County averaged only 104.2 pounds. Wherever the deer population becomes so great that a scarcity of food results, the size and weight of the deer in that area become markedly reduced.

This was the case with the Aberdeen herd, where at the time of Flyger's study deer were over abundant.

Habitat and habits.—Deer are essentially animals of the "edges," preferring burned-over areas and second-growth timber. They are much less common in heavily forested sections because the dense foliage discourages the growth of low forage on which the deer feed. Since much of Maryland today consists of edge habitat, deer are probably even more abundant in the State than they were before the coming of the white man when most of the area was heavily wooded.

Even though much of Maryland was heavily forested in precolonial and colonial days, white-tailed deer were apparently numerous and supplied a good source of food for early settlers. According to Mansueti (1950, p. 13) there are countless references to the abundance of deer in early letters and accounts of conditions of the 17th, 18th, and 19th centuries.

Although deer originally occurred in every Maryland county, the species was almost exterminated from about 1900 until the early 1930's. This was due apparently to high hunting pressure and other factors. For example, Browning (1928) estimated that he killed between 1,800 and 2,000 deer during his hunting career in western Maryland, and that by 1839 the deer in Garrett and Allegany counties were beginning to become scarce. Other factors that were responsible for the decline in the deer herds in Maryland include wild dog packs and forest fires, both of which are known to have killed many individuals throughout the State.

The population increase in recent years has resulted from stocking and intelligent conservation, as well as from the increased "edge" habitat in many areas of the State. Today, the white-tailed deer occurs in all sections of Maryland, and in some places is overabundant. Such an area is the Aberdeen Proving Grounds in Hartford County, where according to Flyger (1958, p. 3) counting 100 or 200 deer in a single morning's observation is not at all unusual, and where a distinct browse line is evident in the woods. At the Proving Grounds, also, there have been several instances of mass die-off in recent years, an indication of overpopulation in a particular area. Flyger found that the deer herd in Cecil County, on the other hand, is still rapidly growing and the range there is more understocked than in any other part of the State.

The Maryland Conservationist (40(1), p. 15, Jan.–Feb., 1963) lists the total deer kill in various Maryland counties for the 1962 season as follows: Garrett 577, Allegany 699, Washington 344, Frederick 214, Carroll 114, Howard 12, Montgomery 2, Anne Arundel 5 Calvert 93, Prince Georges 12, Charles 208, St. Marys 33, Baltimore 95, Cecil

351, Harford 70, Kent 619, Queen Annes 124, Caroline 106, Talbot 180, Dorchester 696, Somerset 192, Wicomico 161, Worcester 377. In addition to the above, 418 deer were killed at Aberdeen Proving Grounds during the season. The Fish and Wildlife Service reports (Big Game Inventory for 1967, Wildlife Leaflet 481, September 1968) an estimated total of 75,000 deer in the State for 1967.

White-tailed deer are primarily nocturnal, but are often abroad during daylight hours. With regard to feeding habits of this species in Maryland and the availability of food within the State, Bitely (1963, pp. 8–9) says:

> Deer require a varied diet and if you've ever watched them feed, they'll nibble here and there, take a twig of witch hazel, then red maple, some huckleberry and for dessert some greenbriar. . . . Whenever possible, they prefer browse, such as greenbriar, maple leaf viburnum, blueberry, sassafras, black oak, red maple and blackberry. After several winters of heavy browsing these species begin to disappear and the deer are forced to shift to less nutritious food.
>
> During the winter a deer requires from 6 to 8 pounds of dry browse each day for body and heat maintenance. If the quality and quantity of food is insufficient they become victims of diseases (especially pneumonia) and parasites. Very few deer in this section of the United States ever actually starve to death; disease usually gets them first.

He says that surveys conducted in 1962 in western Maryland indicated heavy browsing pressure on the preferred foods. For instance, of the twigs within reach and available to deer, the following percentages had been browsed: Maple-leaved viburnum, 53.9; blackberry, 43.8; blueberry, 59.0; black birch, 38.8; black cherry, 14.3; dogwood 33.9; greenbriar, 77.6; hazelnut, 24.1; red maple, 25.9; black oak, 44.4; sassafras, 54.8. In the western three counties, an average of 29 percent of the annual growth was browsed each year. By contrast, on the Eastern Shore, only an average of 6.1 percent was taken. The statewide survey disclosed that a total of 58 species of woody plants had been browsed throughout Maryland.

The following life history notes on the white-tailed deer are extracted primarily from Severinghaus and Cheatum (1956, pp. 57–186).

It is generally agreed that social organization in this species is limited to the family group, which usually consists of an older doe with her fawns, sometimes including those of the previous year. Leadership of the group appears to rest with the old doe. The occasional antlered buck that may be seen with the family group is usually the yearling offspring of the old doe. In the Northern States, the breeding season begins in November and the young are born in May or June. Antlers begin to appear on the bucks in the summer. They grow from a pedicle of the frontal bone and are covered with a true skin (the velvet) during their growth. Antler growth is rapid, usually full size being achieved within 4 months or less. During the period of antler growth, the buck is very careful of the sensitive appendages, but after full size is reached, the velvet is scraped away, and the polished antlers are used by the bucks in battles for mates. The necks of the bucks also swell considerably during the mating season. After the mating season the antlers are shed, usually in January or early February in Northern States, then the cycle continues.

Gestation period in this species varies from 189 and 222 days, with the average being about 201 days. The usual number of young, for older does, is two, occasionally three. A young doe, however, usually gives birth to only a single offspring. The fawns are spotted, and remain in thickets where they blend perfectly with the dappled shadows of the foliage. Both bucks and does generally achieve sexual maturity at 18 months of age, although well-nourished doe fawns, at least in northern areas, may breed at 6 to 8 months of age.

Specimens examined.—*Allegany County:* Cumberland, 3.

Other records and reports.—White-tailed deer have been reported from every county in Maryland.

Remarks.—The subspecies of white-tailed deer that originally inhabited Maryland was *Odocoileus v. borealis.* By the turn of the present century, however, the species was nearly extinct in Maryland, as well as in most other eastern States. Widespread transplanting of deer from areas in which they were still abundant reestablished eastern herds. Deer from many areas, and representing a number of subspecies, were brought into Maryland, and consequently today it is impossible to assign the State's deer to any specific subspecies. According to Hosley (1956, p. 228): "One effect of the widespread transplanting of Lake States deer into the south and east and of other similar moves has been to mix up thoroughly the races existing in most of the deer range."

MARINE MAMMALS OF MARYLAND

The following list of marine mammals comprises only those that have stranded on Maryland beaches, or have been observed in waters off the Maryland coast and in Chesapeake Bay. The list does not include all the marine mammals that may occur in Maryland waters, and many additional species will eventually be discovered. Some of these unrecorded species have stranded on beaches to the north and south of Maryland and must also pass through Maryland waters. Only those, however, which have actually been reported from the State will be discussed in any detail.

Order PINNIPEDIA (pinnipeds)

Family PHOCIDAE (earless seals)

HARBOR SEAL

Phoca vitulina concolor De Kay

Phoca concolor De Kay, Zoology of New York . . . , Vol. 1, pt. 1 (Mammalia), p. 53, 1842.

Type locality.—Long Island Sound, near Sands Point, Nassau County, N.Y.

General distribution.—Along the Atlantic coast of North America from Ellesmere Island to South Carolina, but is rare in the northern and southern portion of this range.

Description.—A small seal that averages in total length about 4 or 5 feet and weighs 75 to 150 pounds. The pelage is coarse and varies from yellowish gray, spotted with dark brown to almost black, spotted with yellowish. The spotted pelage and small size are distinctive characters of this species.

Maryland records.—Harbor seals in Maryland waters are stragglers; they are not indigenous to the State. Mansueti (1950, pp. 28–29; 1955, p. 2) summarizes Maryland records as follows: One specimen taken in a seine in Chesapeake Bay near Elkton in August 1824; one animal feeding around Thomas Pouch Lighthouse, near Annapolis, in March 1894; one animal killed in Tangier Sound on 8 July 1898; one specimen sighted on 14 September 1898 on a beach above reach of heavy waves at Ocean City, Worcester County; several animals in Choptank River near Tilghman Island in the early part of February 1925; one specimen seen in Chesapeake Bay at Flag Pond in 1940; one animal sighted at Ocean City, Worcester County, in May 1955.

In addition, there is a fragmentary skin and partial skeleton of a harbor seal in the National collections; the specimen was found on the beach at Assateague Island, 3 miles south of Ocean City, Worcester County, on 12 May 1959.

HOODED SEAL

Cystophora cristata (Erxleben)

[*Phoca*] *cristata* Erxleben, Systema regni animalis . . . , 1:590, 1777.

Type locality.—Southern Greenland or Newfoundland.

General distribution.—North Atlantic coast from Greenland to Labrador. Newfoundland, Nova Scotia, and Gulf of St. Lawrence, south as an accidental to Florida.

Description.—A large seal, with males ranging up to 10 feet in total length and weighing up to 850 pounds. Females are smaller, averaging about 8 feet in length and weighing up to 400 pounds. Coloration slate-gray to blackish dorsally, with sides paler and spotted with white. Males have a bladderlike protuberence on the nose which they can inflate in times of anger or danger.

Maryland records.—One recorded in 1865 as taken near Cambridge, Dorchester County, on an arm of the Chesapeake Bay, 18 miles from salt water (Cope, 1865, p. 273); one animal killed at Worton Point, near Chestertown, Kent County, about 1860 (Mansueti, 1950, p. 31).

It is possible that the seal from Tangier Sound previously listed as *Phoca vitulina concolor* may have been a hooded seal rather than a harbor seal. The Baltimore Sun of 9 July 1898, which reported the killing of the animal on 8 July 1898, said that it measured almost 6½ feet in length. If this measurement was accurate, the animal would fall within the size range of the hooded seal rather than the harbor seal.

Order CETACEA (cetaceans)

The order Cetacea is divisible into two distinct suborders distinguished primarily by the presence of teeth, or baleen in the mouth. Those that are toothed are classified as:

Suborder ODONTOCETI (toothed whales)

Toothed whales may have teeth in the lower jaws only, or in both upper and lower jaws. In some forms more than 100 teeth are present, while in others the teeth may be reduced to 2. Whales of this suborder never possess baleen.

Family ZIPHIIDAE (beaked whales)

GOOSE-BEAKED WHALE

Ziphius cavirostris G. Cuvier

Ziphius cavirostris G. Cuvier, Recherches sur les ossemens fossiles . . . , ed. 2, 5: 352, 1823.

Type locality.—Near Fos, Bouches-du-Rhone, France.

General distribution.—In the western North Atlantic, reported from Newport, Rhode Island, south to St. Simon Island, Ga.

Description.—A medium-sized whale, ranging up to 28 feet in length. The body is thickset and has a strongly marked median keel extending from the dorsal fin to the tail. The color pattern is extremely variable; the back is usually a purplish black and the underparts white. Males have a single tooth projecting an inch or more beyond the gum at the end of each lower jaw.

Maryland records.—On 5 September 1959, a whale of this species was sighted alive north of Fenwick Island, Del. It stranded that night at

Maryland Beach, Worcester County. This is the only Maryland record, although specimens have stranded at other localities to the north and south of the State.

Family PHYSETERIDAE (sperm whales)

SPERM WHALE

Physeter catodon Linnaeus

[*Physeter*] *catodon* Linnaeus, Syst. Nat., ed. 10, 1: 76, 1758.

Type locality.—Kairston, Orkney Islands, Scotland (by restriction, Thomas, Proc. Zool. Soc. London, p. 157, 22 March 1911).

General distribution.—In western North Atlantic from Iceland and Davis Straits, south to Gulf of Mexico, West Indies, Lesser Antilles, and coast of Venezuela.

Description.—This species is the largest of the toothed whales, males sometimes reaching a length of 60 feet or more. Females are considerably smaller, generally under 40 feet in length. In coloration this whale is a uniform gray or dark bluish gray. The narrow lower jaw contains 20 to 30 heavy teeth. Usually no teeth are visible in the upper jaws. There is no dorsal fin.

Maryland records.—Only one sperm whale is known to have stranded on a Maryland beach. It came ashore at Green Run Inlet (now closed) just north of the Maryland-Virginia boundary on Assateague Island in December 1891. This specimen is preserved as a skeleton in the U.S. National Museum.

At times, sperm whales are numerous off Ocean City. They attract the attention of passing boats by their habit of raising their flukes clear of the water when sounding.

PIGMY SPERM WHALE

Kogia breviceps (Blainville)

Physeter breviceps Blainville, Ann. d'Anat. et de Physiol., 2: 337, 1833.

Type locality.—Region of Cape of Good Hope, Republic of South Africa.

General distribution.—In western North Atlantic recorded from Halifax Harbor, Nova Scotia, south to Jupiter Inlet, Florida. This is a pelagic species that is seldom found stranded on beaches.

Description.—A small edition of its larger relative the sperm whale, the pigmy sperm whale ranges in length from 9 to 13 feet. In coloration it is black above, white beneath. There are usually 14 or 15 small needlelike teeth in each lower jaw; no teeth visible in upper jaws. This species, unlike the large sperm whale, possesses a small dorsal fin.

Maryland records.—The pygmy sperm whale is known from Maryland by a live specimen that came ashore at Ocean City, Worcester County, in August 1959. Vacationers at the beach repeatedly tried to push the small whale back to sea. Eventually, during a high tide the animal worked its way into deeper water where it struggled away. The stranding of this whale is discussed in detail by Manville and Shanahan (1961, pp. 269–270).

Family DELPHINIDAE (porpoises and dolphins)

ATLANTIC DOLPHIN

Delphinus delphis Linnaeus

[*Delphinus*] *delphis* Linnaeus, Systema naturae, ed. 10, 1: 77, 1758.

Type locality.—European seas.

General distribution.—In western North Atlantic recorded from Iceland and Woods Hole, Massachusetts, south to Bahama Islands and Jamaica.

Description.—This is a small Cetacean, reaching a length of about 8 feet. The animal possesses a slender "beak" about 6 inches long, which is sharply marked off from the sloping forehead by a deep V-shaped groove. The mouth contains many sharp pointed teeth that interlock perfectly and are adapted for catching and holding the fish upon which the dolphin preys. In coloration, this species is blackish dorsally, including the dorsal surfaces of the flukes and pectoral apendages. The sides shade in coloration to a grayish green, mixed with eliptical bands of whitish on the flanks. The abdomen is white and there is a whitish band over the forehead with a narrow black band in the center that connects the black eye rings. Often there is a black band from the snout to the leading edge of the pectoral fin.

Marlyand records.—No records of strandings of this species are available from Maryland, but Charles O. Handley, Jr., says (unpublished manuscript): "In September 1959, Mike Freeman of Washington, D.C., told me of having seen two kinds of porpoises in unusual abundance off Ocean City, Md., and running the Ocean City Inlet into Sinepuxent Bay. His descriptions indicated *Tursiops truncatus* and *Delphinus delphis.*"

This cetacean is probably one of the most abundant in Maryland waters, but it prefers deeper waters off shore, and hence is less likely to strand than several other less numerous species.

BOTTLE-NOSED PORPOISE

Tursiops truncatus (Montague)

Delphinus truncatus Montague, Mem. Wermerian Nat. Hist. Soc., 3: 75, 1821.

Type locality.—Totness, Devonshire, England.

General distribution.—In the western North Atlantic recorded from Massachusetts south to Florida.

Description.—Adults of this species reach a length of 11 or 12 feet, and may be recognized by the purplish lead-gray coloration of the upper parts, the short beak, seldom more than 3 inches long, and the lower jaw, which is slightly longer than the upper. There are 20 to 26 teeth on each side in both jaws of the mouth.

Maryland records.—True (1890, p. 197) says that he has been informed that this species ascends the Potomac River as far as Glymont, a fishing station on the Maryland shore about 18 miles below Washington, D.C.

On 27 and 28 July 1884, a porpoise, presumed to be of this species, was observed in the Potomac River above the Aqueduct Bridge in Washington, D.C. It was chased by boats and shot at repeatedly, but not captured. The species has been seen at various times near Alexandria (unsigned note in The Pastime, 3(2), p. 14, August 1884).

In the Chesapeake Bay, *Tursiops* has been reported as far up as Havre de Grace, Harford County (Maryland Tidewater News, 8, p. 40, 1952).

Specimens in the National collections are from the following Maryland localities: Point Lookout, St. Mary's County; Queenstown Creek, Queen Annes County; and Scientist's Cliffs, Calvert County.

In addition, bottle-nosed porpoises are often seen off Ocean City, Worcester County, and swimming in the Ocean City Inlet into Sinepuxent Bay. This is probably the most abundant marine mammal in Maryland waters.

Suborder MYSTICETI (baleen whales)

Whales of this suborder do not possess teeth. Instead, they are equipped with whalebone, or baleen, which hangs down in the mouth from either side of the upper jaws in long strips, with hairlike bristles on the inner edges. The apparatus thus formed serves as a strainer. In feeding, the baleen whales swim open-mouthed through swarms of plankton; then closing the mouth, they press the tongue against the baleen plates, squeezing out the water and leaving the plankton inside the mouth to be swallowed.

Family BALAENOPTERIDAE (fin-backed whales)

LITTLE PIKED WHALE

Balaenoptera acutorostrata Lacépède

Balaenoptera acutorostrata Lacépède, Histoire naturelle des Cétacée . . . , p. 37, 1804.

Type locality.—European seas.

General distribution.—Adults of this species apparently winter in tropical or warm temperate waters, and summer in cold temperate and boreal waters. Young animals, however, may frequent warm or temperate waters during the summer months. In the western North Atlantic, adults have been reported during the summer from Iceland and Greenland south to New Jersey and the Delaware River. There are records of this species in Florida waters during winter months. (see Schwartz, 1962, pp. 206–209).

Description.—The little piked whale resembles a small fin-backed whale in appearance, but is of somewhat stouter build. Adults reach a length of about 30 feet. There are approximately 50 ventral grooves in the throat region, and the baleen is entirely yellowish white in color. The body is blue-gray on the back and white on the abdomen.

Maryland records.—This species has been recorded from Maryland only once. On 12 July 1959, an immature female stranded at Dares Beach, Calvert County, in Chesapeake Bay. Schwartz (1962) discusses this specimen and its stranding in detail.

FIN-BACKED WHALE

Balaenoptera physalus (Linnaeus)

[*Balaena*] *physalus* Linnaeus, Systema naturae, ed. 10, 1: 75, 1758.

Type locality.—Spitzbergen Seas (See Thomas, Proc. Zool. Soc. London, 1911, pt. 1, p. 156, 22 March 1911).

General distribution.—In western North Atlantic, from Iceland and Greenland south to the Gulf of Mexico and Caribbean Sea.

Description.—This is a large baleen whale, the adults measuring between 50 and 65 feet in total length. The coloration is velvety black except for a small ash-colored area at the tip of the lower jaws, a cream-colored chin and throat and occasionally white or piebald underparts. The undersurface of the body in the region of the throat has numerous longitudinal grooves. The dorsal fin is high and triangular, usually with a concave posterior border. The baleen in this species exhibits asymmetry in coloration, the blades on the right side being white for more than a third of the distance from the tip of the snout and the remainder on that side, and all of the left side, being colored a dull blue-gray with streaks of white and yellow. This whale is known as the greyhound of the ocean because of its slender build and great speed in swimming.

Maryland records.—The type specimen of *Sibbaldius tectirostris* Cope (a species now regarded as a synonym of *Balaenoptera physalus*) washed ashore on the Maryland coast near Sinepuxent Inlet, Worcester County, in the winter 1868–69. The skull of this specimen is now in the U.S. National Museum collections.

There is a report in the Maryland Tidewater News (1953) that a whale 60 feet in length was stranded at Ocean City, Worcester County, in the spring of 1953 which probably was of this species.

Fin-backed whales are more numerous off the Maryland coast than these two stranding records would indicate.

BLUE WHALE

Balaenoptera musculus (Linnaeus)

[*Balaena*] *musculus* Linnaeus, Systema naturae, ed. 10, 1: 76, 1758.

Type locality.—Firth of Forth, Scotland (see Thomas, Proc. Zool. Soc. London, 1911, pt. 1, p. 156, 22 March 1911).

General distribution.—In the western North Atlantic, from Iceland and Greenland south to Panama.

Description.—This is the largest animal that ever lived, either on land or in water. Adults sometimes reach lengths in excess of 100 feet, the largest specimens usually being females. The color of this species is slate blue over the whole body with the exception of the tip and undersurface of the flippers, where pigmentation is absent. The blue coloration may be modified by a pale mottling that is sometimes diffused and sometimes concentrated in patches in different parts of the body. There are between 80 and 100 ventral throat grooves and the baleen in the mouth is jet black.

Maryland records.—This species is known from Maryland by a single specimen that grounded near Crisfield, Somerset County, in the summer of 1876. The skeleton of this juvenile individual, identified by G. S. Miller, Jr., is now in the museum of the Natural History Society of Maryland in Baltimore.

Remarks on Maryland Marine Mammals

The above list is composed only of species that have stranded or been observed off the Maryland coast. Many other species undoubtedly pass through Maryland waters and will someday be recorded for the State. Some, such as the short-finned blackfish (*Globicephala macrorhyncha*) and the Atlantic blackfish (*Globicephala melaena*), have stranded on beaches only a few miles south of the Maryland State line. The following is a list of species, presently unrecorded for the State, which probably occur at some time or other in Maryland waters:

Harp seal, *Phoca groenlandica* Erxleben.
Dense-beaked whale, *Mesoplodon densirostris* (Blainville).
Gulf Stream beaked whale, *Mesoplodon europaeus* (Gervais).
Northern beaked whale, *Mesoplodon mirus* True.
Striped porpoise, *Stenella coeruleoalbus* (Meyen).

Atlantic killer whale, *Grampus Orcinus* (Linnaeus).
Atlantic blackfish, *Globicephala melaena* (Traill).
Short-finned blackfish, *Globicephala macrorhyncha* Gray.
Harbor porpoise, *Phocoena phocoena* (Linnaeus).
Sei whale, *Balaenoptera borealis* Lesson.
Hump-backed whale, *Megaptera novaeangliae* (Borowski).
Right whale, *Eubalaena glacialis* (Borowski).

EXTIRPATED RECENT MAMMALS OF MARYLAND

Mansueti (1950) has discussed in detail the extirpated Recent mammals of the State. He lists six species that at one time occurred within Maryland but have vanished since the coming of the white man. As pointed out by Handley and Patton (1947, p. 78):

> Though it is regretable that man has had a hand in the extinction of these creatures, he is not to be blamed too much, for the ascendency of one species and the extinction of another is a regular process of nature which has been repeated over and over again all down through the ages. Probably man did not have much or anything to do with the disappearance of wild horses, mammoths, mastodons, tapirs, wild pigs, ground sloths and camels which once roamed our lands, but they are gone nevertheless. As surely as a species of animal comes into being, it is destined to eventual extinction, whether by geologic catastrophies such as volcanic eruptions or earthquakes; or by great climatic changes involving vast spreading glaciers or desert wastes, or by the hand of man. Our geologists have given us proof of all this by the fossil record in the rocks.

The six species of extirpated Recent mammals of Maryland discussed by Mansueti (1950) are:

PORCUPINE

Erethizon dorsatum (Linnaeus)

This species apparently never was widely distributed in Maryland, nor was it ever abundant. Mansueti cites records from Allegany County; Blue Ridge Mountains; Frederick-Washington Counties; and Ellicott City, Howard County (all of these prior to 1881). Rhoads (1903, p. 115) cites porcupine records from Fulton and Somerset Counties, Pa., adjacent to Maryland on the north. The Cumberland (Maryland) Sunday Times for 9 August 1964 reported that recently a porcupine was shot on a farm at Rocky Gap, east of Cumberland. A photograph of this animal accompanied the news release. This may represent a valid state record, or the animal may have been brought to Maryland from elsewhere. This same article in the Cumberland Sunday News reports that in 1912 a boy in Frostburg brought some quills to school from a porcupine he found dead on Mount Savage. It also says that during the fall of 1948 a hunter reported his dogs found a porcupine on Martins Mountain for they returned to him with their noses full of quills. He was not able, however, to locate the porcupine. The foregoing serves to show that there are records and reports of the porcupine in the western part of Maryland right up to the present day. The general consensus of opinion, however, regarding the status of this animal is that it is no longer a native inhibtant of the State.

GRAY WOLF

Canis lupus Linnaeus

The gray wolf originally inhabited the entire State of Maryland. Not only are there documents and publications to show that they were at one time statewide in distribution (see Mansueti, 1950, pp. 25–26), but the early settlers used the name "wolf" to designate many places throughout the State. The Gazeteer of Maryland (Maryland State Planning Comm., and Dept. of Geology, Mines and Water Resources, October 1941, p. 230) lists the following place names in Maryland that give a good idea of where early colonists found wolves: *Allegany County:* Wolf Gap, Wolf Rock; *Baltimore County:* Wolftrap Branch; *Caroline County:* Wolfpit Branch; *Carroll County:* Wolfpit Branch; *Frederick County:* Wolf Rock; *Garrett County:* Wolf Den Run, Wolf Gap, Wolf Swamp; *Somerset County:* Wolf Trap Creek. Mansueti (1950, p. 25) says that they even abounded on Assateague Island in Worcester County.

All evidence seems to indicate that the gray wolf was exterminated in Maryland at a very early date, except for those in more inaccessible parts of western mountains. Here the species probably persisted until late in the 19th century, and perhaps even to the early part of the present century.

MARTEN

Martes americana (Turton)

The marten was exterminated in Maryland as far back as 85 years ago. It apparently was not widespread in distribution, and never abundant. Heavy trapping pressure and destruction of suitable forest habitat appear to account for its demise. It was probably most abundant in the western part of the State, but there are reports from the District of Columbia and perhaps St. Marys County (see Mansueti, 1950, p. 23).

MOUNTAIN LION

Felis concolor Linnaeus

This species at one time occurred throughout the State, wherever there were white-tailed deer, which served as it principal food. The mountain lion was hunted with relentless energy by settlers and at very early date was exterminated from all but the wildest portions of the western part of the State. The date when the last mountain lion was killed in Maryland is not known, but it was probably sometime toward the end of the 19th century. In the 18th century, the species appears to have been abundant in the mountains of Maryland. Meshach Browning (1928) estimated that he killed more than 50 of them during his active period as a hunter in Garrett County from 1790 to 1836. There is no question that today, however, the species is extinct in Maryland despite the fact that from time to time there are reports of them in some of the more remote portions of the State. None of these recent reports of mountain lions in Maryland have ever been verified, and it seems that the species has been extirpated in the entire Eastern United States, with the exception of Florida where a few still persist in the swamps and hammocks in the Everglades.

WAPITI OR ELK

Cervus canadensis (Erxleben)

This species was at one time statewide in distribution. Mansueti (1950, pp. 11–12) lists a number of early references to it, not only from the mountains of the west, but also in the Tidewater. Its former occurrence within the State is attested to by the number of places that bear the name "elk." Thus, there is an Elklick Run in Anne Arundel County, Elklick Run in Garrett County, Elk Mills, Elk Neck, Elk River, and Elkton in Cecil County, Elk Mountain and Elkridge in Washington County, Elkridge in Harford County, Elkridge in Howard County, and Elkridge in Baltimore County. The last of Maryland's wapiti were apparently exterminated long before the middle of the 19th century. McAtee (1918, p. 52) places the date of their extirpation in Virginia as 1844.

BISON

Bison bison (Linnaeus)

According to Mansueti (1950, p. 10) the distribution of bison in Maryland and the District of Columbia must have been above the fall line. The bison thus was an inhabitant of the Piedmont, Ridge and Valley, and Allegheny Mountain sections of the State. When the first settlers arrived, however, the species was already becoming scarce, and these settlers hastened its demise, exterminating the bison in Maryland by 1775. The Glades Star (publication of the Garrett County Historical Society) for 1943, says that around 1774 one of the Ashbys (early settlers in the Glades of Garrett County) and a neighbor were searching for the neighbor's cows one day in early winter. They followed the tracks of some animals in the light snow until they came to what is now the J. J. Ashby farm, when Ashby saw a bunch of wooly hair on a snag. Following the trail still farther to the hill southeast of the present town of Grellin, they spotted 4 bison. They shot the bulls and the cows escaped westward. These were the last seen in the Glades, and probably the last of Maryland's bison herd.

The former occurrence of the bison is still indicated by such place names as: Buffalo Road (Carroll and Frederick Counties); Buffalo Run, Little Buffalo Run, and Buffalo Marsh (Garrett County).

Mansueti (1950) lists 2 additional species (fisher, *Martes pennanti;* and Canada lynx, *Lynx canadensis*) that may have occurred in Maryland in the past but are not presently a part of the fauna of the State. There is no good evidence, however, that either of these species ever ranged as far south as Maryland.

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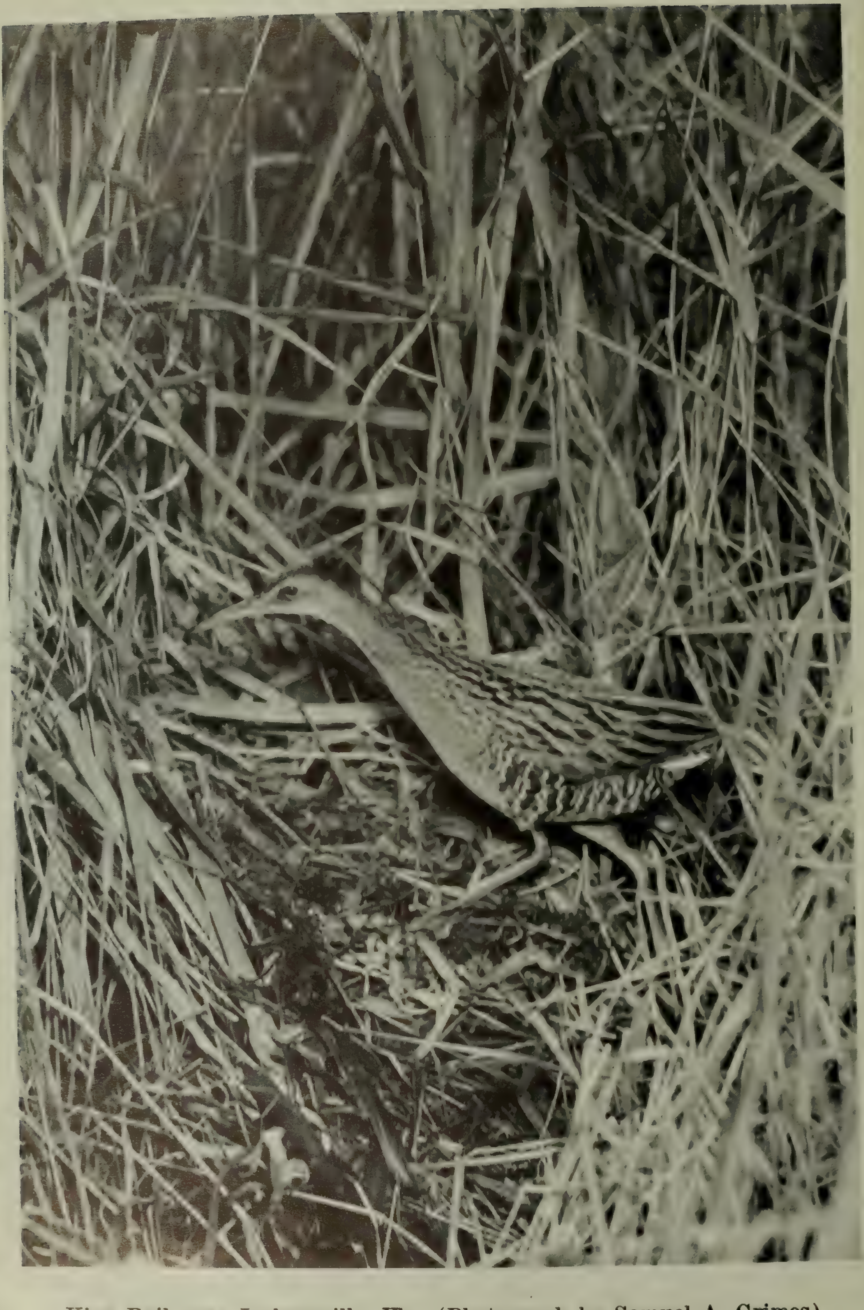
OF THE
KING RAIL



King Rail near Jacksonville, Fla. (Photograph by Samuel A. Grimes)

NATURAL HISTORY
OF THE
KING RAIL

By Brooke Meanley, *Wildlife Biologist*

Patuxent Wildlife Research Center
Division of Wildlife Research
BUREAU OF SPORT FISHERIES AND WILDLIFE

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Photographs are by the author unless otherwise credited.

Introduction

The King Rail (*Rallus elegans* Audubon), largest of North American rails, is indeed an elegant bird, as its Latin name implies. Its striking appearance (fig. 1), secretive nature, and association with a variety of wetland habitats make it a favorite of bird students and rail hunters. The King Rail is found in most of the eastern half of North America, from the Atlantic coast to the Great Plains and from the Gulf of Mexico to southern Canada. It is most abundant in the fresh and brackish tidal marshes of the Atlantic and Gulf Coastal Plain, the domestic ricefields of Arkansas, Louisiana, and Texas, and the marshes of southern Florida. It is fairly common in parts of the Midwest Prairie and Great Lakes region.

I began my studies of this interesting bird in 1950 in the Arkansas ricefields, and have continued them until 1967, both in the field and in the laboratory.

Many of the field observations, particularly those of courtship behavior, were made from an automobile which served as an admirable mobile blind. Such a blind was used to follow courting rails along roadside ditches in Arkansas and Louisiana, making it possible to study the detailed nuptial courtship behavior of 20 different pairs and the prenuptial behavior of four. Under these conditions it was possible also to distinguish the sexes by their behavior rather than by their size differences, which are sometimes difficult to ascertain in the field.

The highly vocal nature of the King Rail and its characteristic calls, varying with different conditions, enhance the value of field observations and made the call-count census a practical technique. Studies of growth and development of the young were made with captive birds, which are quite tractable if obtained early in life from nests or hatched from eggs in incubators.

Studies of breeding biology were made mostly on the Arkansas Grand Prairie in the vicinity of Stuttgart from 1950 through 1955. Subsequent studies on life history and ecology were made at Mamou, Evangeline Parish, La.; Broadway Meadows near Woodland Beach, Kent County, Del.; the Pee Dee River at Georgetown, S.C.; the Savannah National Wildlife Refuge, Jasper County, S.C.; and the Patuxent Wildlife Research Center, Laurel, Md.

I have supplemented my own observations with a review of the published studies of others and have attempted to bring all information on the King Rail together into a monographic treatment.

My discussions in this paper include the history of the discovery of the King Rail as a distinct species by Audubon in 1834 and its systematic position in relation to the Clapper Rail, as taken mostly from the literature. The discussions of other topics are largely from my own observations, but supplemented with literature reports. The principal topics include distribution and migration; ecological relations; physical characteristics; breeding biology; development and behavior of captive rails; foods and feeding; mortality factors; and the King Rail's position as a game bird. Appendixes include methods of capturing and banding and a list of local names. Aquatic plant names used in the text are from Hotchkiss (1950) unless otherwise indicated.

I am indebted to many persons for assistance with this project. Anna Gilkeson Meanley, my wife, assisted with the fieldwork over a 7-year period in Arkansas and Louisiana. E. R. Kalmbach, former Director of the Denver Wildlife Research Center, made the sketches of courtship displays and offered encouragement and many suggestions during the early phases of the study in Arkansas. Other colleagues from the Bureau of Sport Fisheries and Wildlife who were most helpful in various phases of the work include Nancy C. Coon, John W. Aldrich, Van T. Harris, Lucille F. Stickel, Paul A. Stewart, Robert E. Stewart, Charles C. Sperry, Neil Hotchkiss, Francis M. Uhler, Frederick C. Schmid, Glen Smart, Johnson A. Neff, Robert G. Heath, Luther C. Goldman, and David K. Wetherbee. Anthony J. Florio of the Delaware Game and Fish Commission was helpful in Delaware studies. I am grateful to Samuel A. Grimes of Jacksonville, Fla., for his photograph of a King Rail used as the frontispiece.

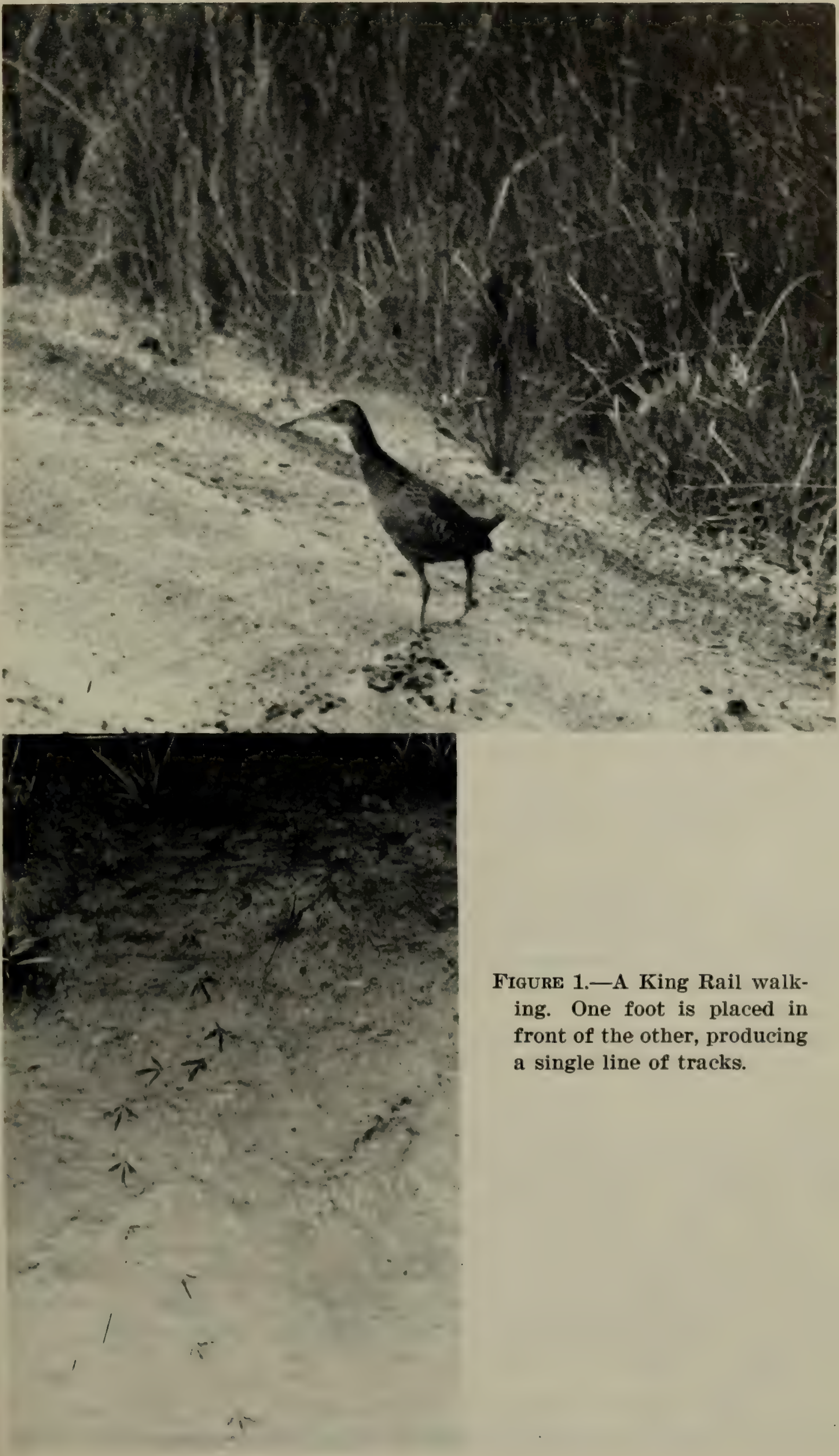

FIGURE 1.—A King Rail walking. One foot is placed in front of the other, producing a single line of tracks.

History and Systematic Position

HISTORY

John James Audubon published the first description of the King Rail as a distinct species. The Great Red-breasted Rail or Fresh-water Marsh Hen, as he called it, was introduced with the publication of his painting in *Birds of America* (Audubon, 1834, plate 203). A year later a description of this new rail appeared in his *Ornithological Biography* (Audubon, 1835, p. 27–32).

Alexander Wilson, Audubon's predecessor, encountered this same species but thought it was the adult form of the Clapper Rail (*Rallus longirostris*), "following the current opinion of gunners that it was a very old example of that species" (Stone 1908, p. 110). Elaborating on this point, Audubon (1835, p. 27) stated:

> No doubt exists in my mind that Wilson considered this beautiful bird merely the adult *Rallus crepitans* [*Rallus longirostris crepitans*], the manners of which he described, as studied at Great Egg Harbour, New Jersey, while he gave in his works the figure and colouring of the present species. My friend, Thomas Nuttall, has done the same, without, I apprehend, having seen the two together. Always unwilling to find fault in so ardent a student of nature as Wilson, I felt almost mortified when, after having in the company of my worthy and learned friend, the Reverend John Bachman, carefully examined the habits of both species, which in form and general appearance, are closely allied, I discovered the error which he had in this instance committed. Independently of the great difference as to size between the two species, there are circumstances connected with their habits which mark them as distinct. The *Rallus elegans* is altogether a fresh-water bird, while *R. crepitans* never removes from the salt-water marshes . . .

J. d'Arcy Northwood (1956, p. 224), commenting on Audubon's discovery, said:

> The king rail was one of Audubon's scoops. Here was a large rail, not particularly rare, that lived unknown and undescribed under the noses of the experts in Philadelphia. Audubon realized that it was distinct from the clapper rail of the salt marshes, with which it had been confused, and named it the Great Red-breasted Rail or Fresh-Water Marsh Hen.

The type locality given in the American Ornithologists' Union *Check-list of North American Birds* (1957, p. 152) is Kentucky, South Carolina, Louisiana, and north to Camden, N.J., and Philadelphia = Charleston, S.C.

Although Audubon collected and observed the King Rail in several localities prior to his field studies in company with Bachman in the

Charleston, S.C., region, it is apparent from his original description (Audubon, 1835) that he finally decided that it was indeed a new species on the basis of their work in that region. It would seem that the species distinctness may even have been brought to his attention by Bachman, who in a letter to Audubon sent from Charleston, S.C., and dated December 27, 1832, posed this question:

> May not the Northern Marsh Hen, be the Bird which we here call the Fresh Water M. Hen & our Ash coloured one that keeps to the Marsh be peculiar to the South? I should like to have this matter ascertained.

In a letter from Charleston dated March 27, 1833, Bachman, again referring to the Marsh Hen, said (Deane, 1929, p. 180, 184), "My opinion first expressed [in the letter of December 27, 1832] is every day strengthened."

Audubon (1835, p. 27–28) reported that he caught a female at Henderson, Ky., on May 29, 1810, and also collected a female near Camden, N.J., in July 1832.

Stanley C. Arthur (1937, p. 503), a biographer of Audubon, believed that Audubon's painting of the Fresh-water Marsh Hen was made at New Orleans in 1821 when he spent the winter, spring, and fall there. Audubon obtained birds from the city market and from two hunters engaged to collect for him, and painted over 100 birds from this area (including work in the St. Francisville area in West Feliciana Parish). An entry in Audubon's journal, dated December 20, 1821 (Corning 1929, p. 224), says that he "Rec^{d} a nondescript rail." And an entry made the next day says, "Drew a streaked Rail." This may have been a King Rail, but if it was, apparently it was not recognized as a new species at that time.

An interesting letter from Rodolphe M. deSchauensee, Curator of Birds at the Academy of Natural Sciences in Philadelphia, dated February 7, 1962, sheds some light on the possibility of an existing type specimen or cotype:

> I have gone into the question of the type specimen of the King Rail mentioned in your letter of February 1 with what I think are interesting results.
>
> Some years ago Fletcher and Phillips B. Street gave to the Academy a collection of birds which had belonged to Edward Harris who was a friend of Audubon. On looking through our collection I found in this lot an immature specimen of the King Rail. In vol. 3 (p. 28) of Audubon's Ornithological Biographies he says "I killed one female in New Jersey, a few miles from Camden, in July, 1832 in company with my friends Edward Harris and Mr. Ogden . . ."
>
> In the Elephant Folio (vol. 3) pl. 203 engraved in 1834 two birds are shown, an adult and an immature. The bird in Harris's collection agrees very well both in color and measurements with the bird depicted as the immature specimen. As the bird was collected in 1832 the plate engraved in 1834 and Audubon's original description published in 1835, there is every reason to suppose that this is the bird shown on the plate.
>
> In view of all the above I feel that it is justifiable to regard this specimen as a cotype. Audubon described an adult male, a female and an immature. If

these three birds all existed today they would of course all be cotypes. In the plate the female is not figured, only the adult male and young.

If this specimen were to be accepted as a cotype, the type locality would have to include Camden, N.J. However, in his original description of *R. elegans*, Audubon (1835) said that most of his observations of this species were in South Carolina.

SYSTEMATIC POSITION

The King Rail belongs to the order Gruiformes, which in North America includes the cranes, limpkins, rails, gallinules, and coots. Birds of this group mostly inhabit wetland environments, particularly marshes.

The suborder Grues includes the families Gruidae (cranes) and Aramidae (limpkins). Rails, gallinules, and coots belong to the suborder Ralli, which contains a single family, Rallidae. In North America this family comprises seven genera and nine species.

The three North American species of the genus *Rallus*, *R. elegans* (the King Rail), *R. longirostris* (the Clapper Rail), and *R. limicola* (the Virginia Rail), have laterally compressed bodies which facilitate passage through dense marsh vegetation; rather long, slender, and slightly curved bills which are as long as or longer than the tarsi, and longer than the heads; large, strong legs; long, slender, unwebbed toes; short, rounded wings (with vestigial claws); short, tip-up, pointed tails less than half as long as the wings; flanks conspicuously barred with white; olive or grayish dorsal regions which are striped with black or dusky markings; and buffy or rufescent breasts. *R. elegans* is larger than *R. limicola*, which it resembles in color, and is more rufescent than races of *R. longirostris* but is about the same size as that species.

Two races of the King Rail are generally recognized: *Rallus elegans elegans* of North America, and *Rallus elegans ramsdeni*, the Cuban form. Apparently a third form, *Rallus elegans tenuirostris*, occurs in the fresh-water marshes of the Valley of Mexico. There is a difference of opinion concerning the systematic position of *tenuirostris*, some authors assigning it to *Rallus elegans* and others to *Rallus longirostris*. The recent work of Warner and Dickerman (1959) seems to indicate that the plumage and inland distribution of this form are more like that of *Rallus elegans*.

RELATIONSHIP TO THE CLAPPER RAIL

Some ornithologists believe that King and Clapper Rails are merely races of the same species. Structurally and behaviorally they are similar. The plumages of several Clapper races closely resemble that of the King Rail. Their breeding ranges overlap in numerous coastal brackish marshes, in at least one of which there is absolute evidence of interbreeding resulting in the production of viable eggs.

Oberholser (1937, p. 314–315), in discussing the relationship of these two species, stated that—

> it remains yet to determine the status of the king rail, *Rallus elegans*, of the Eastern United States, and its single subspecies, *Rallus elegans ramsdeni*, of Cuba. This is an unusually difficult matter to decide, and one concerning which there may well be difference of opinion. The chief external characters separating the king rails from the clapper rails consist in the much more reddish bend of the wing, and in the rich rufescent-olive tinge of the upper parts of the former birds, this involving both the centers and margins of the feathers. There is little or no trenchant difference in behavior, voice, nest building, or other habits between these two species. Neither one of the external characters of plumage above mentioned, nor any difference in size or proportions, is entirely trenchant when all the races of *Rallus longirostris* are included.

The occurrence of King and Clapper Rails in the same breeding grounds has been observed by several ornithologists. Robert E. Stewart (personal communication) observed a King and a Clapper Rail together with brood at Chincoteague Island on the coast of Virginia in June 1951. He has also on numerous occasions observed King and Clapper Rails together in the tidal marsh along Ape Hole Creek, a tributary of Pocomoke Sound, Somerset County, Md. H. M. Stevenson reported seeing a Clapper Rail walking directly in front of a King Rail at Alabama Point, Ala., June 6, 1965 (Stewart, J. R., 1965, p. 553). In April 1956, I collected a King Rail and a Clapper Rail from the same pond at Grand Chenier, Cameron Parish, La. In this area, the narrow chenier (stranded rim of the sea or old shoreline) serves somewhat as a barrier between the fresh and salt marsh, and these two species merely have to walk a hundred yards or so to be together. It is difficult to separate the two species in the field in the gulf coast marshes, although the breast of the resident Clapper race, *R. l. saturatus*, is duller brown in contrast to the more rufescent breast color of the King Rail.

On the South Atlantic coast, Ivan R. Tomkins (1958, p. 11) encountered a similar situation near Savannah, Ga. He wrote:

> This brackish area, a place of transition from fresh to salt, has some peculiar situations in respect to bird habitats. In the middle of Elba Island I have seen both King and Clapper Rails on territory so close together that both birds were in view at the same time.

In the New York City region, John Bull (1964, p. 169) reported 11 specimens and 19 sight records of King Rails in coastal salt marshes and a January record of two King Rails feeding with a Clapper Rail on a mud flat at Lawrence.

On May 18, 1960, John S. Webb and I observed a King Rail and a Clapper Rail together in a brackish tidal marsh along the Delaware Bay near Fleming's Landing, Kent County, Del. The mated pair (fig. 2) were observed on their nesting territory on numerous occasions thereafter and were collected on June 11. The nest was also located on that date, and the five eggs were removed and placed in an incubator. Despite the fact that optimal incubation conditions were main-

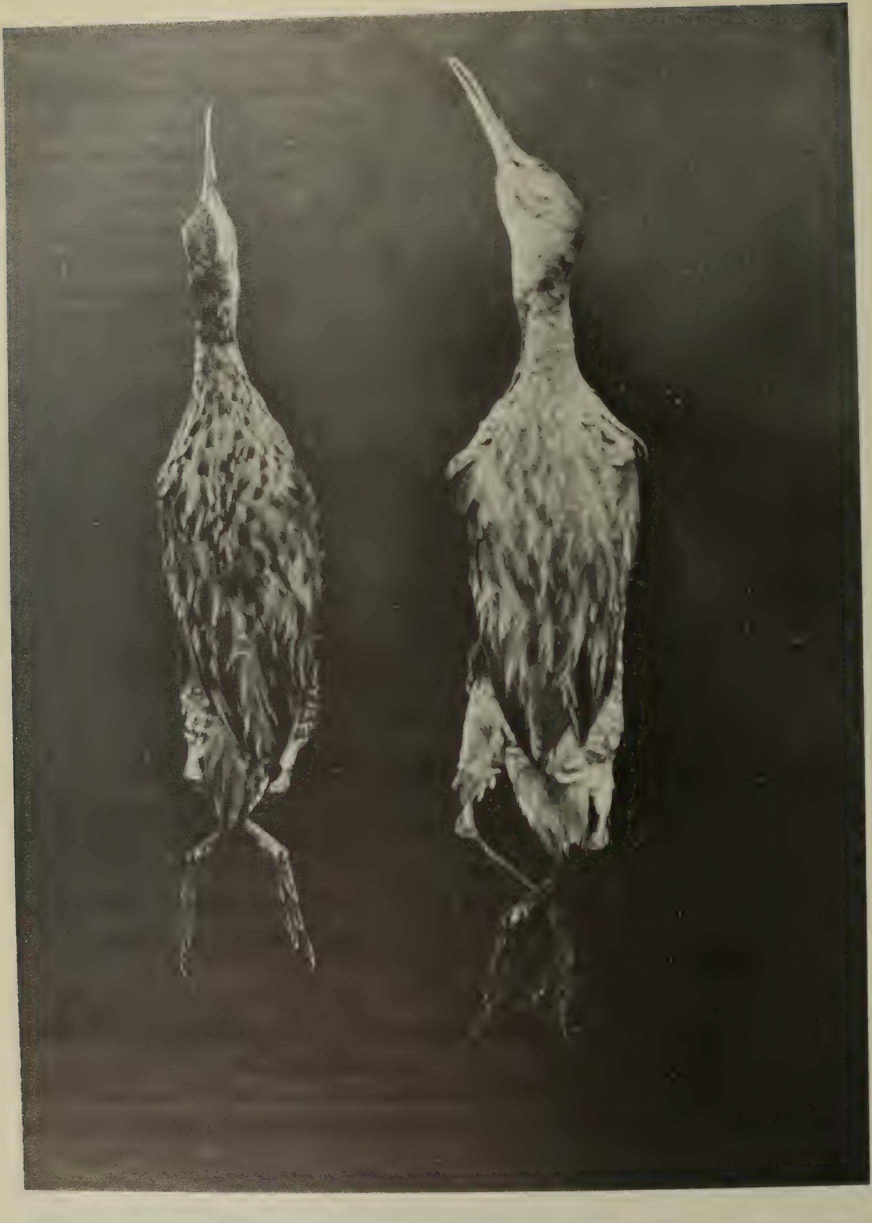

FIGURE 2.—Mated King Rail (subadult female) left, and Clapper Rail (adult male) right, collected at Taylor's Gut, Kent County, Del., June 11, 1960. Eggs of pair were fertile. (Photograph by Frederick C. Schmid.)

tained (64 percent relative humidity and 37.8° C. forced draft) (Wetherbee, 1959) the embryos died between the 17th and 19th days of incubation. The embryos appeared to be normal, and the deaths were believed to have been accidental rather than indicative of genetic incompatibility.

Subsequent observations revealed that King and Clapper Rails frequently were found together in the extensive brackish bay marshes in the Taylor's Gut area known as Broadway Meadows and located between Fleming's Landing and Woodland Beach, Del. (Meanley and Wetherbee, 1962, pp. 453–457; Meanley, 1965, pp. 3–7).

During the breeding seasons of 1960–64, a series of specimens was collected in the Broadway Meadows marsh for plumage analysis. Specimens were obtained at three stations: (*a*) the upper reaches of the brackish marsh at Fleming's Landing, where King Rails only were observed; (*b*) the outer brackish marsh at Woodland Beach on Delaware Bay, where Clapper Rails only were observed; and (*c*) the intermediate area between these two stations at Taylor's Gut, where both Kings and Clappers occurred. Specimens from the intermediate area showed a wide variation from typical King plumage to typical Clapper plumage (table 1).

In addition to the localities mentioned, there are undoubtedly many other such areas in the brackish marshes of the Atlantic and Gulf Coastal Plain where mixed King Rail and Clapper Rail populations occur. In fact, almost any Coastal Plain river that has extensive brackish marshes and a sizable fiddler crab population is a potential King-Clapper mixing ground.

TABLE 1.—*Specimens randomly collected from Taylor's Gut, Del., an area of mixed King and Clapper Rail populations*

Species and age	Sex	Collection date
King Rail:		
Adult	Male	May 13, 1961
Do	Female	Apr. 15, 1963
Do	do	Aug. 23, 1963
Do	do	May 29, 1964
Do	do	July 30, 1964
Subadult	do	[1] June 11, 1960
Do	do	June 30, 1960
Juvenile	do	July 14, 1964
Clapper Rail:		
Adult	Male	[1] June 11, 1960
Do	do	June 25, 1960
Do	do	June 29, 1964
Do	Female	May 13, 1961
Do	do	Aug. 30, 1963
Hybrid(?):		
Adult	Male	Aug. 23, 1963
Do	do	Do.
Do	Female	Aug. 30, 1963

[1] Paired and active nest found.

Distribution and Migration

DISTRIBUTION

Unlike the Clapper Rail, which in the eastern United States is mainly restricted to a rather narrow band of salt marshes along the Atlantic and gulf coasts, the King Rail is found throughout the eastern half of North America. In general, its breeding range extends from the Gulf of Mexico to southern Canada and from the Atlantic coast to about the 100th meridian in the Great Plains (fig. 3).

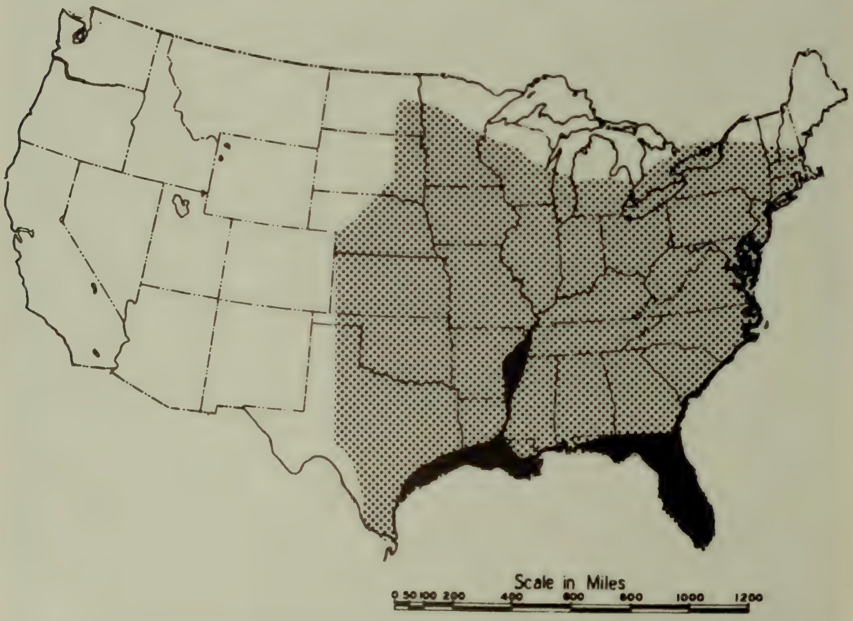

FIGURE 3.—Approximate breeding range and principal distribution of the King Rail in North America (black shaded area along Gulf and Atlantic Coasts and in Lower Mississippi Valley and peninsular Florida indicates main wintering range).

The boundaries of the breeding range as given in the American Ornithologists' Union Check-list (1957, p. 152) and supplemented by additional records, mostly from the distribution files of the Section of Migratory Non-Game Bird Studies, Migratory Bird Populations Station, Laurel, Md., and from *Audubon Field Notes*, are as follows: The northern boundary extends from southeastern North Dakota (western Dickey County), central Minnesota (Otter Tail and Hennepin Counties), southern Wisconsin (Jamesville, Madison, Racine), central Michigan (Saginaw Bay), southern Ontario (St. Clair Flats to Toronto), and New York (Buffalo, Branchport, Ithaca, Long Island), to Massachusetts. The western boundary extends from southeastern North Dakota, eastern Nebraska, western Kansas (Cheyenne and Meade Counties), and central Oklahoma, to southern Texas (Corpus Christi). Collections of specimens at Brownsville, Tex., on September 27, 1911, and April 2 (year not given) (Griscom and Crosby, 1925, p. 527) suggest the possibility of breeding in that area. The eastern boundary extends from Massachusetts southward along the Atlantic coast to the southern Everglades. The southern boundary includes the gulf coast region, in places virtually to the edge of the gulf itself.

Records of occurrence near or beyond the limits of the normal breeding range are as follows: St. John's, Newfoundland (October 20, 1935); Wellington, Prince Edward Island, Canada (March 28, 1917); Ottawa, Ontario (May 7, 1896); Crane Lake, Ontario (July 31, 1931); Port Perry, Ontario (April 21, 1923); Bucksport, Maine (November 22, 1909); Fargo, N. Dak. (October 15, 1925); Key West, Fla. (November 2, 1895); Dry Tortugas, Fla. (May 1961) (W. B. Robertson, personal communication); and Tlacotalpan, Veracruz, Mexico (January 18, 1901).

The King Rail's principal wintering range coincides with that part of the breeding range where the species is most abundant, in the tidewater country from the Delaware Valley to southeastern Georgia, and southward through interior Florida into the Everglades, westward through the gulf coast marshes and the rice belts of Louisiana and Texas, and north into the Arkansas rice belt.

The King Rail is a regular winter resident along the Atlantic coast as far north as New York City and in the Mississippi Valley to southeastern Missouri. Southernmost winter records in the United States are from the Lower Rio Grande Valley, in the vicinity of Brownsville, Tex. (December 28, 1911, and January 10, 1923) (Griscom and Crosby, 1925, p. 527).

Some of the numerous winter records (mainly from the distribution files of the Section of Migratory Non-Game Bird Studies, Migratory Bird Populations Station, Laurel, Md.) north of the principal winter range are as follows: LaSalle, Ontario (December 15, 1930); Lorne Park, Toronto, Ontario (December 26, 1960); Falmouth, Maine (December 17, 1899); Cambridge, Mass. (December 30, 1896); Cape Cod, Mass. (December 30, 1951); Hillsdale, Mich. (December 11, 1896); Detroit, Mich. (February 6, 1907); Port Huron, Mich. (December 6, 1902); Vicksburg, Mich. (February 6, 1909); Prudensville, Mich. (December 7, 1938); Monroe County, Mich. (December 30, 1934, and February 8, 1934); Bayside, Long Island, N.Y. (December 24, 1924); Miami and Meade Counties, Kans. (late December); and Montauk Point, Long Island, N.Y. (December 27, 1951).

In the New York City region, Bull (1964, p. 169) reported 15 winter specimens, 5 in December, 7 in January, 1 in February, and 2 the first week in March. Eleven of the fifteen were taken in salt marshes, and there were 19 sight records in salt marshes, nearly all in December and January.

On the basis of extensive field observations by several ornithologists, including Robert E. Stewart, Milton B. Trautman, D. J. Nicholson, T. D. Burleigh, Oliver H. Hewitt, and myself, and as a result of an intensive literature review, the most important areas of concentration probably have been determined.

The King Rail occurs in greatest numbers in the vast coastal marsh and ricefield area of southern Louisiana. Other areas supporting high populations include the coastal marsh–rice belt of Texas; the Arkansas rice belt; the fresh and brackish tidal marshes of the Carolinas and Georgia; the Everglades, the Kissimmee Prairie, and the St. Johns River marshes of Florida; and the tidal marshes of the Delaware Valley and Chesapeake Bay. The Lake Erie marshes of northern Ohio and the St. Clair Flats opposite Detroit, Mich., are two important concentration areas in the North Central States.

MIGRATION

Throughout most of its range the King Rail is migratory. Evidence of movements between wintering and breeding grounds is based on recoveries of banded birds, and birds heard calling overhead at night, striking beacons, and appearing in odd places such as city streets during periods of migration.

The Atlantic Coastal Plain, particularly its outer section, and the Mississippi Valley are important flyways of the King Rail. The occurrence of King Rails near the Atlantic coast during migration is due to movements to and from breeding grounds in that area. King Rails commonly breed at many places less than 50 miles from the coast. Several known localities include Butler Island near Darien, Ga.; Savannah National Wildlife Refuge, Jasper County, S.C.; Georgetown, S.C.; Currituck Sound, N.C.; Norfolk, Va.; the coastal sea islands and Delaware Bay marshes.

A King Rail collected by I. N. Gabrielson in the Atlantic coast salt marshes at Wachapreague, Va., August 25, and several taken by hunters in September at Chincoteague, Va., indicate the probable route of migration of at least some northeast Atlantic coast breeding birds.

During 7 years' residence in the lower Mississippi Valley, I heard migrating King Rails regularly every spring at Alexandria, La., and

Stuttgart, Ark. On the night of March 11, 1956, single King Rails were heard calling as they migrated northward over the city of Alexandria at 8:30, 9:30, and 11 p.m. They appear to be less vociferous while migrating in the fall. The most commonly uttered call of migrating King Rails is a *chur-r-r-r-r* (the *r* like the German "R"). Another call occasionally given is *chac-chac-chac-*.

Probably most fall migration takes place after molting, which is completed about the first of September. In Delaware, I have collected flightless birds in the last week in August that would still have been flightless through the first week in September. However, some rails collected in late August had nearly or completely renewed their flight feathers.

The fall departure schedule for three species of rails at the Patuxent Wildlife Research Center, Laurel, Md., was determined by a trapping and banding program extending from midsummer to early winter. King Rails were the first to leave the area (the last by late September); they were followed by Soras (the last by early November), and lastly by Virginias (the last of December).

David C. Hulse (personal communication) wrote that a definite influx of King Rails is noticed annually at Decatur, northern Alabama, in late September: "Local birds are still here and at this time must be augmented by migrants. Departure is gradual and by late October rails become gradually scarce."

King Rails breeding at the southern limit of their range in the gulf coast region are probably permanent residents or may perform short coastwise migrations.

Winter records for the Middle Atlantic and North Central States suggest the possibility of permanent residency by some individuals. In the Chesapeake Bay region of Maryland there are two records of King Rails banded in August and recovered in the same marsh the following January. Also, a 6-week-old chick banded July 12, 1968, at the Patuxent Wildlife Research Center, Laurel, Md., was recovered December 12, 1968, at the same place.

As of January 1966 there have been only two recoveries of King Rails that migrated an appreciable distance from the point of banding. Only one of these was a direct recovery (bird recovered within 12 months of banding date). A 2-week-old chick was banded at Stuttgart, Arkansas County, Ark., on June 2, 1952, and recovered at Cut Off, Lafourche Parish, La., December 1, 1952, having traveled a distance of about 350 miles. The other recovery concerned a King Rail banded at Lassie, Wharton County, Tex., June 9, 1949, and recovered at Brookville, Montgomery County, Ohio, 1,000 miles away, on May 2, 1951. A King Rail banded at Ruthven, Palo Alto County, Iowa, August 25, 1951, and recovered at Lake View, Sac County, Iowa, September 10, 1951, had traveled some 60 miles and was probably migrating.

Spring arrival and fall departure dates are given in table 2. Some of these dates are questionable; those for the interior northern part of the range may be more reliable than those along the Atlantic coast where so many King Rails winter.

LOCAL MOVEMENTS

Information on local movements was obtained at two marshy impoundments at Patuxent Wildlife Research Center, Laurel, Md., during the summers of 1965 and 1966. In 1965, four pairs of King Rails nested in an impoundment known as Knowles Unit 2; in 1966, no King Rails nested there because of deep water. Knowles 2 has an area of 20 acres, of which about 10 acres are shrub swamp or marsh or a mixture of the two. Knowles Unit 1, the other impoundment, is larger, but contained only about 6 acres of marsh and shrub swamp at the time. One pair of King Rails nested there in 1965 and 1966.

TABLE 2.—*Spring arrival and fall departure dates for migrating King Rails*

Location	Arrival	Departure	Source
Mississippi Flyway:			
Stuttgart, Ark	Feb. 15 to Mar. 30	Mid-October to mid-November.	Meanley, unpublished.
Missouri	Mar. 21 to 31	Late October	Widmann, 1907, p. 59.
Buckeye Lake, Ohio	Apr. 11 to 20	Late September	Trautman, 1940, p. 229.
Chicago, Ill	Mid-April	Late October	Ford, 1956, p. 33.
Knox County, Ind	Apr. 15 to 30		Section of Migratory Nongame Bird Studies, Migratory Bird Populations Station, unpublished.
Kansas	Apr. 18 (median date)		Johnston, 1964, p. 611.
Vicksburg, Mich	Apr. 19	Oct. 10 (latest)	Rapp, 1931, p. 7.
Southern Michigan	Apr. 21 to May 10	Late August through September.	Wood, 1951, p. 146–147.
Southern Minnesota	Late April	Late September	Roberts, 1936, p. 440.
Clay County, Iowa	May 1 to 7	Early September	Tanner and Hendrickson, 1956, p. 54.
Decatur, Ala		Late October	Hulse, personal communication.
Atlantic Flyway:			
Raleigh, N.C	Late March		Brimley, 1917, p. 299.
Western Pennsylvania	Mid to late April		Todd, 1940, p. 183–184.
New York, N.Y	Late April		Cruickshank, 1942, p. 156.
Connecticut River Valley Massachusetts and Connecticut.		September, early October.	Bagg and Eliot, 1937, p. 178–180. Sage and Bishop, 1913, p. 48.
Broadway Meadows Kent County, Del.		September	Meanley, unpublished.
Laurel, Md		September	Meanley, unpublished.

One of a pair of nesting King Rails trapped and banded on June 12, 1965, in Knowles 2, was first recaptured on August 2, approximately 200 yards from where it was banded. This bird was recaptured a second time on August 7, approximately 350 yards from the second site and 500 yards from the original site.

The young of the 1965 nest in Knowles 1 were hatched on July 2 and 3. Earlier, one of the adults was banded and color-marked while incubating. Both adults and the brood remained within 100 feet of the nest most of the time until at least July 24, a period of 3 weeks.

On July 8, 1966, the same color-marked adult, its mate, and their brood of eight 2-week-old chicks were trapped in Knowles 1, 50 feet from where the color-marked adult had nested the previous year. The unbanded adult and the chicks were banded when trapped.

On July 16, two of the eight chicks were captured and the rest of the family was observed on an island in Knowles 2, 0.4 mile from the site of their original capture in Knowles 1 on July 8. To reach the island in Knowles 2, the 3-week-old flightless chicks had not only walked nearly half a mile but had swum across 50 feet of open water that had a depth of 3 feet.

Ecological Relations

The King Rail probably occurs in a wider variety of habitats than any other rail. The species ranges from coastal salt and brackish marshes to shrub swamps and occasionally is found even in upland fields near marshes where it forages for grasshoppers and grain, and where it sometimes nests.

The distribution of the King Rail's habitat coincides rather closely with that of the muskrat (*Ondatra zibethicus*). Muskrats create optimum habitat for rails by opening up marshes and producing networks of pathways leading to plunge holes. When the tide goes out, water is trapped in the holes, and rails use them as drinking places. Muskrat trails are also favorite places for crayfish burrows. The crayfish are a prime food of the rails and are usually carried to the tops of muskrat houses for eating.

Because of the geographic as well as the local variation in habitats of the King Rail, the ecological relations will be discussed on a regional basis.

This chapter will cover both my own observations on the ecology of the King Rail in Louisiana, Arkansas, South Carolina, Delaware, and Maryland, and those of other authors in different States or areas.

LOUISIANA GULF COAST MARSHES

The King Rail and the Louisiana Clapper Rail, a brownish form virtually indistinguishable from the King Rail in the field, occur together in some sections of the Louisiana coastal marsh. This vast marsh area of more than 4 million acres is divided into three major divisions, each of which is a distinct habitat type and will be discussed separately: the delta marsh, subdelta marsh, and prairie marsh (St. Amant 1959, p. 97–101) (fig. 4).

The delta marsh

The delta marsh, near the mouth of the Mississippi River, comprises only 7 percent of the total coastal marsh area of Louisiana. Important plant species of the delta marsh are cattails (*Typha spp.*), roseau cane or reed (*Phragmites communis*), common three-square (*Scirpus americanus*), dog-tooth grass (*Panicum repens*), giant cutgrass (*Zizaniopsis miliacea*), saltmarsh cordgrass (*Spartina alterniflora*), delta duck potato (*Sagittaria platyphylla*), alligatorweed (*Alternanthera philoxeroides*), and water hyacinth (*Eichhornia crassipes*).

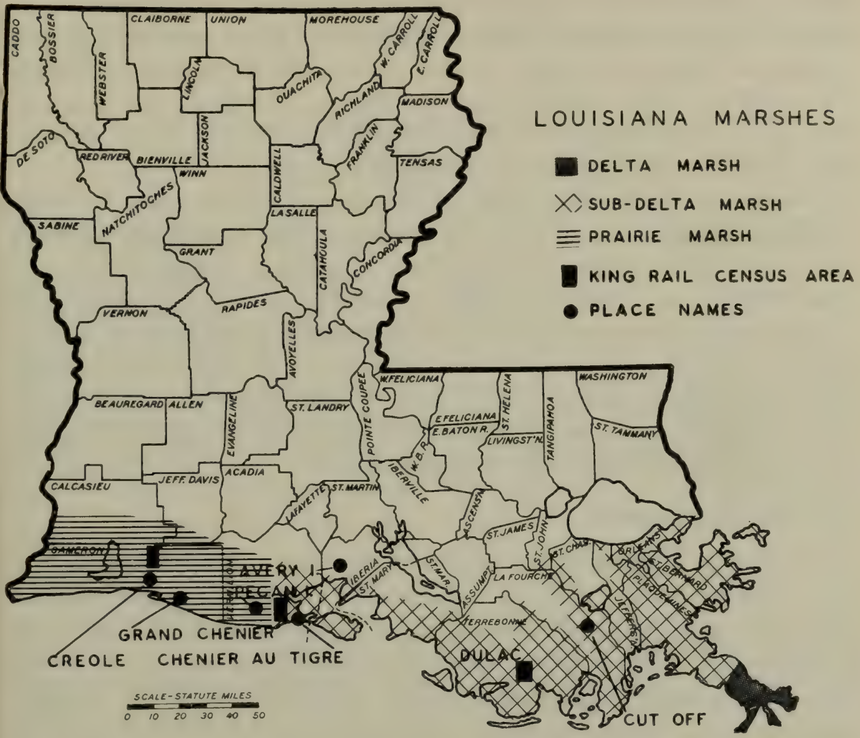

FIGURE 4.—Louisiana gulf coast marshes.

Oberholser (1938, p. 109, 201) reported the collection of a King and six Clapper Rails in the delta marsh at the mouth of the Mississippi River, indicating their presence in this habitat type.

The subdelta marsh

The subdelta marsh, comprising 74 percent of the Louisiana coastal marsh, extends westward from the Mississippi River Delta to Cow Island and Chenier au Tigre in Vermilion Parish. Both its fresh-water and brackish marshes are of two types, floating or with a firm floor of clay. The predominant plant species in both types is "paille fine" or maidencane (*Panicum hemitomon*). Associated with it are cattail, southern bulrush (*Scirpus californicus*), sawgrass (*Cladium jamaicense*), wapato (*Sagittaria latifolia*), alligatorweed, and water hyacinth. In brackish areas either saltmeadow cordgrass (*Spartina patens*) or Olney's three-square (*Scirpus olneyi*) is dominant; the latter is dominant if there is management (burning) for muskrat production. Salt marshes in this area are dominated by needlerush (*Juncus roemarianus*), saltmeadow cordgrass, and saltmarsh cordgrass.

Both banding returns and collections of birds substantiate the occurrence of King Rails in the subdelta marsh. A King Rail banded at Stuttgart, Ark., in June 1952, was recovered at Cut Off, Lafourche

Parish, in the subdelta marsh, in December 1952. Cut Off is approximately 25 miles south of New Orleans. King Rails were collected at Chenier au Tigre, January 1, 3, and 5, 1934, by A. M. Bailey (Oberholser 1938, p. 199); at the same location on March 31 and April 1, 1947, by I. N. Gabrielson; and at Avery Island, May 7, 11, 13, and 15, 1930, by E. G. Wright (Oberholser, 1938, p. 199).

I made a census, based on calls, in Terrebonne Parish, 1.2 miles south of Dulac, on January 3, 1963, to determine the abundance of King Rails in the area (table 3). The birds were heard calling from what appeared to be an abandoned silted-in canal where shallow ponds were interspersed with dense patches of vegetation dominated by clump grass (*Spartina spartinae*). In a 1-mile strip, 50 feet wide, 19 King Rails were counted. Short-billed Marsh Wrens (*Cistothorus platensis*), Soras, Virginia Rails, and Common Gallinules (*Gallinula chloropus*) were also common in this same census strip.

The prairie marshes

The prairie marshes in the southwestern part of the Louisiana gulf coast (Vermilion and Cameron Parishes) comprise 19 percent of the total area. Near the gulf coast much of the prairie marsh is bisected by ridges known as cheniers (stranded rims of the sea or old shoreline) that parallel the coast (fig. 5). Cheniers extend in straight lines for many miles and in most places are wide enough only for a

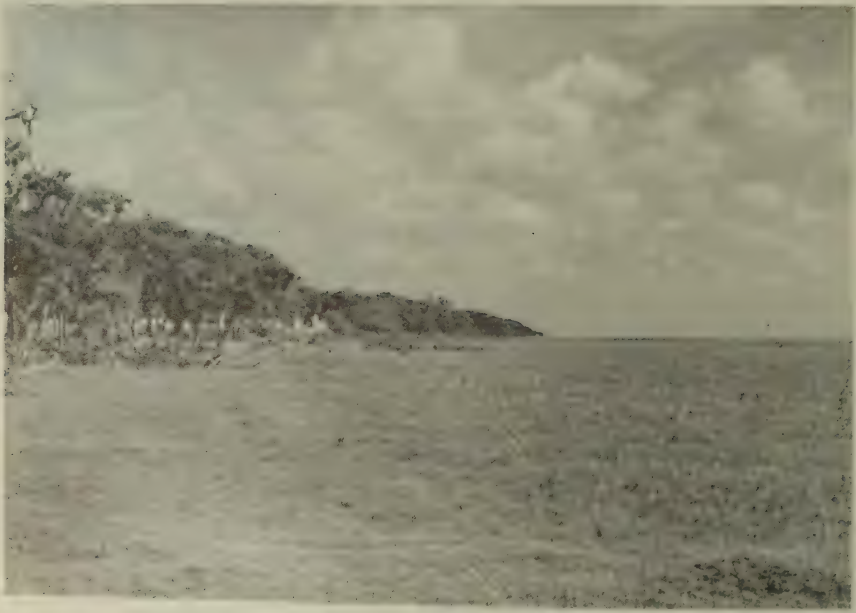

FIGURE 5.—Prairie marsh, Grand Chenier, La., March 1956. Mixed King and Clapper Rail populations sometimes occur in the same marsh type in this area. Both species were collected from the same half-acre pool near here, April 1956.

road bordered on each side by a line of live oaks. In some places there are a few houses. In some sections, cheniers separate fresh and brackish marshes.

TABLE 3.—*Abundance of King Rails in certain areas, as indicated by censusing*

Location	Number of King Rails	Date	Cover type
Black and Pedee Rivers, Georgetown County, S.C.	25 in 100 acres [1] [2]	Apr. 10–12, 1961	Giant cutgrass, cattail, big cordgrass, arrow-arum.
Savannah River, Jasper County, S.C.	14 in 13 acres [1] [3]	Apr. 20, 1961	Softstem bulrush.
10 miles south Fellsmere, Indian River County, Fla.	30 in 100 acres [3]	May 8, 1964	Maidencane.
Savannah National Wildlife Refuge, Jasper County, S.C.	46 along 7-mile route [4]	Apr. 12, 1960	Giant cutgrass, cattail, sawgrass.
Dulac, Terrebonne Parish, La.	19 along 1-mile route [4]	Jan. 3, 1963	Clump grass, or needle cordgrass.
4 miles north Creole, Cameron Parish, La.	24 along 1-mile route [4]	Jan. 5, 1963	Fall panicum.
3 miles north Pecan Island, Vermilion Parish, La.	20 along 1-mile route [4]	Jan. 4, 1963	Fall panicum.
Stuttgart, Arkansas County, Ark.	22 along 6-mile route [4]	Apr. 1955	Rice stubble, broom-sedge, cattail, softrush.

[1] Males only.
[2] Two-stage sampling.
[3] Strip census.
[4] Roadside count.

In this area salt marshes near the coast are dominated by a saltgrass–saltmeadow cordgrass–saltmarsh cordgrass association. Landward from this association, brackish marshes extend north to the Creole and Grand Chenier ridges. Principal plants of the brackish marsh are saltmeadow cordgrass, Olney's three-square, and saltmarsh bulrush (*Scirpus robustus*). In the transition areas between brackish and fresh water, such plants as giant cutgrass, bull tongue, pickerelweed (*Pontederia cordata*), and wild millet (*Echinochloa crusgalli*) grow. The fresh-water marshes lie mainly north of the Grand Chenier and Creole ridges. In the higher parts of those marshes the following plants are found: bull grass (*Paspalum boscianum*), lake grass (*Paspalum distichum*), dotted smartweed (*Polygonum punctatum*), squarestem spikerush (*Eleocharis quadrangulata*), and delta duck potato. Sawgrass is the climax type in the lower parts of the freshwater marsh.

In the vicinity of the cheniers, King and Clapper Rails occur close to one another or together. Referring to this situation, Lowery (1955, p. 227) made the following statement:

> The King and Clapper Rails are extremely similar in appearance and are, for the most part, simply ecological representatives of each other. The former generally inhabits fresh-water marshes and is widespread in the interior of the United States; the latter is always found on or near the seacoast in brackish- or salt-water marshes. . . . There are brackish marshes in which both breed side by side without intermingling; . . .

I find it difficult to believe that the two species do not interbreed in the prairie marshes. Several King-Clapper pairs (and their nests and eggs) have been collected recently in Delaware brackish marshes, indicating that they do sometimes interbreed when they occur together (Meanley and Wetherbee, 1962, p. 453–457).

Near the village of Grand Chenier, I collected both Kings and Louisiana Clapper Rails from the same small pond on the south side of the chenier. The dominant vegetation in the immediate area was clumpgrass. On the south side of this narrow chenier, in the brackish marshes, the gulf coast form of the Clapper Rail is the dominant species, but the marsh on the landward side is the King Rail's domain. Rivers, such as the Mermenteau, and canals crossing the chenier extend the brackish water landward, and occasionally storm tides also affect large areas of the marsh, extending salt water into the freshwater zone and changing the habitat. This area may well be described as a mixing ground of plants and animals. A common avian associate of the rails breeding in the clumpgrass and saltgrass marsh was the Mottled Duck (*Anas fulvigula*).

I also encountered four King Rail broods, still in downy black plumage, and three single adults 4 miles north of Grand Chenier on July 23, 1955. At this station the marsh was composed of a mixture of southern bulrush, cattail, a *Sagittaria*, probably *lancifolia*, and water-hyacinth.

A census of King Rails, based on calls, was made in a marsh bordering the Pecan Island road, 2 miles south of the old Intracoastal Canal, Vermilion Parish, on January 4, 1963. Twenty birds were counted in 20 minutes along a 1-mile strip approximately 200 yards wide, at 6 p.m. (table 3). The dominant vegetation in the census area was fall panicum (*Panicum dichotomiflorum*). A similar census was made 5 miles south of the Intracoastal Canal on the east side of the road to Creole, Cameron Parish, on January 5, 1963. Between 5:30 p.m. and 6 p.m. 24 birds were counted along a 1-mile strip approximately 200 yards wide (table 3). The dominant vegetation types in the area were southern bulrush and fall panicum (fig. 6). Soras were also abundant in the same habitat.

SOUTHERN RICEFIELDS

The gradual shift in the domestic rice (*Oryza sativa*) growing industry from the South Atlantic coast to the South Central States of Louisiana, Texas, Arkansas, and Mississippi after the Civil War opened up a new marsh habitat for King Rails and other water birds. Much of the land where rice is grown today was once a vast natural tall-grass prairie in which the Greater Prairie Chicken (*Tympanuchus cupido*) was abundant. Harmon, Thomas, and Glasgow (1960, p. 153) reported that approximately 3 million acres in this area were devoted to rice growing by 1958, and that this acreage wintered 4 million ducks and geese. Many aquatic plants grow in ricefields, and

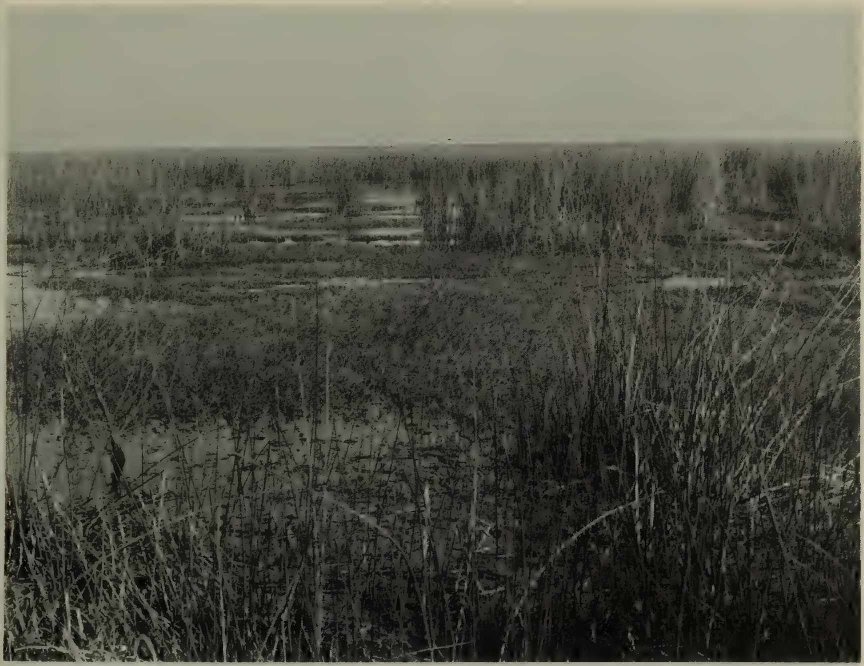

FIGURE 6.—Southern bulrush (*Scirpus californicus*), fall panicum (*Panicum dichotomiflorum*), and alligatorweed (*Alternanthera philoxeroides*) in prairie marsh type near Creole, Cameron Parish, La., January 5, 1965. Between 5:30 and 6 p.m., January 5, 1963, 24 King Rails were counted along a 1-mile transect through this marsh.

virtually all produce seeds utilized by a variety of water birds. Ricefields furnish an optimum all-purpose habitat for King Rails for nearly 6 months during the summer half of the year, and a source of food for them in winter (fig. 7).

On the gulf coast prairie of Louisiana and Texas, rice planting begins in March. Some early varieties are harvested by late July, but most fields are harvested from early August to early October. The planting season in Arkansas is about 2 weeks later, and harvest is from late August to early November. The fields are irrigated by wells or by canal systems fed from reservoirs or bayous. Water remains on the fields for 3 or 4 months and is maintained at a constant level of from 6 to 10 inches.

On the Arkansas Grand Prairie I found the nesting density of King Rails in one ricefield to be at least one nest per 15 acres, a figure based on the location of five nests in a 75-acre field in July. These nests were located by a team of men walking abreast and systematically covering the field to remove a pest plant, the coffeebean (*Sesbania exaltata*). The height of the nesting season was several months past, and these nests probably represented a renesting effort or a second

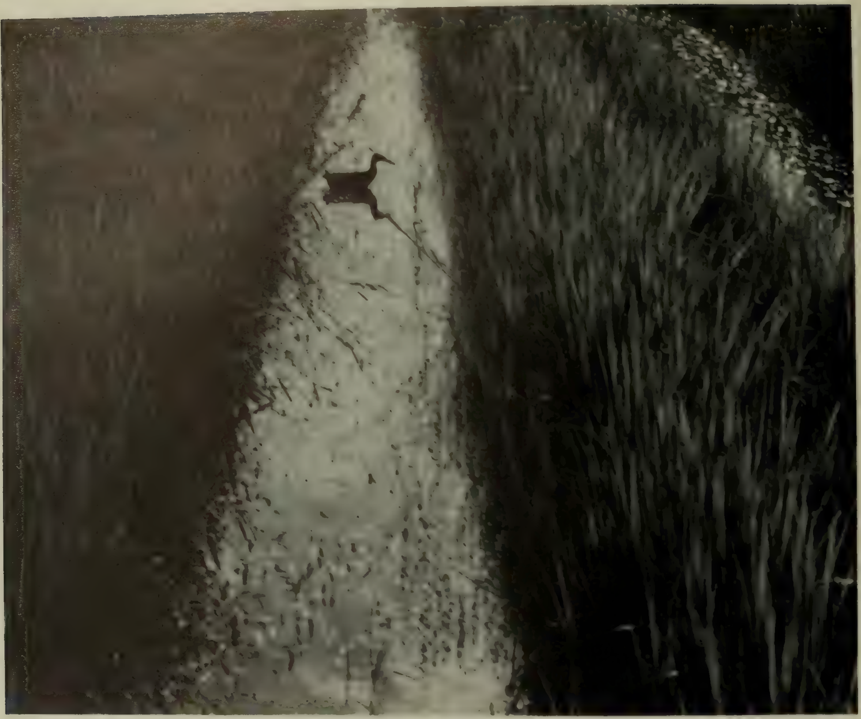

FIGURE 7.—King Rail wading through ricefield toward nest on dike, Stuttgart, Ark., July 13, 1952.

nesting after an earlier first successful nesting. It is not to be construed that this is an average nesting density for Grand Prairie ricefields.

Since much of the rail nesting in rice country is completed before the rice is high enough to provide nesting cover, a better idea of nesting density could be obtained from nest counts or mating call counts in the spring when most of the rails are found in roadside ditches and canals and occasionally in rice stubble. As an example, in April 1955 I located 22 occupied nesting territories along 6 miles of continuous roadside ditch beginning 2 miles north of Stuttgart, Ark. (table 3 and fig. 8).

In Evangeline and Jefferson Davis Parishes in Louisiana I found many nests in roadside ditches where the dominant vegetation was paille fine (maidencane) and softrush (*Juncus effusus*). In Arkansas Grand Prairie ditches in 1952 and 1953, nests were found mainly in stands of softrush, cattail, common spikerush (*Eleocharis palustris*), and lake sedge (*Carex hyalinolepis* and *C. lacustris*), a plant which grows to a height of 3 feet or more and forms very dense stands that persist intact through the winter. Lake sedge was available for nesting cover earlier than any plant in the roadside ditches. Ten years

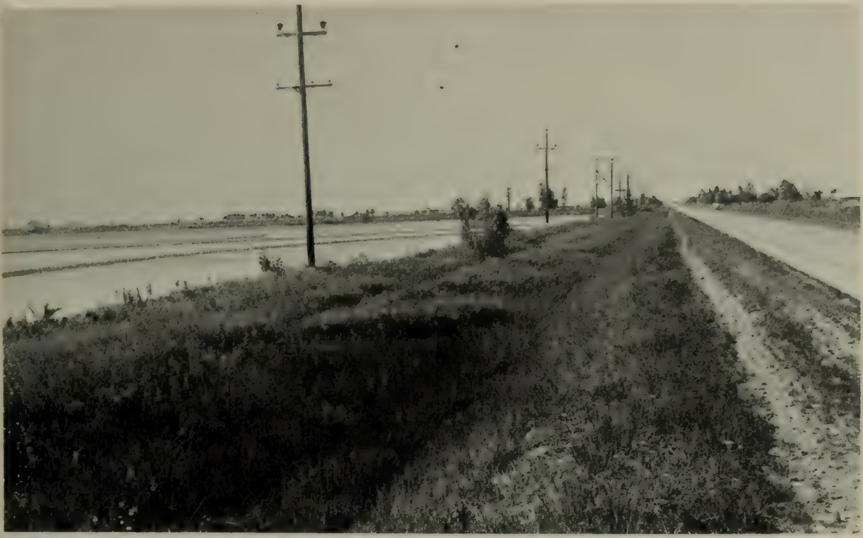

FIGURE 8.—Arkansas Grand Prairie near Stuttgart, Ark., May 1952. Rails nest in roadside ditches in April and May. Vegetation in ditches is mostly softrush (*Juncus effusus*) and two sedges (*Carex stipata* and *C. hyalinolepis*). In June, rails move into ricefields (left of ditch) for late nesting or renesting as rice begins to form nesting cover.

later (1962), in those same ditches, awl-fruited sedge (*Carex stipata*) was the dominant plant, and four of six nests located during May of that year were constructed of this plant.

Old rice stubble is sometimes used for nesting. On the southwestern Louisiana rice prairie where farming is less diversified than on the Arkansas Grand Prairie, many farmers let the stubble fields lie out through the winter and spring for cattle grazing. In one such wet stubble field at Mamou, Evangeline Parish, I located two rice-straw nests on May 5, 1957 (fig. 9).

During the summer, when the rice is growing and the fields appear as a vast green marshland, virtually all King Rails in the rice belt frequent the fields. Some are renesting, and others are wandering about with their broods in search of crayfish, minnows, and aquatic insects which abound here.

Nesting associates of the King Rail in Louisiana ricefields are the Fulvous Tree Duck (*Dendrocygna bicolor*), the Purple Gallinule (*Porphyrula martinica*), the Least Bittern (*Ixobrychus exilis*), and along the southern border of the rice belt the Mottled Duck. The most common bird in the area is the Red-winged Blackbird (*Agelaius phoeniceus*). In the northern part of the principal Louisiana rice belt, at Mamou, Evangeline Parish, I found the Long-billed Marsh Wren (*Telmatodytes palustris*) nesting in rice.

FIGURE 9.—Nest of King Rail in wet rice stubble, Mamou, La., May 5, 1957. Photographed as found.

In 1955 a rice farmer at Mamou located six Fulvous Tree Duck nests in a 400-acre block of rice, and in the same locality I found 22 active Purple Gallinule nests in a 10-acre section of a 25-acre ricefield. In the Arkansas ricefields the Purple Gallinule is an uncommon breeding bird. There are no breeding records for the Fulvous Tree Duck in Arkansas ricefields, but there are several early fall occurrence records. The Short-billed Marsh Wren has been found nesting in Arkansas ricefields in August and September.

King Rails are more secretive in winter than at other seasons and often are present in good numbers in some localities although seldom or never seen. For 5 years in the Arkansas rice belt, I was in the field daily without ever seeing one in the dead of winter. Yet they were present, as a mink trapper brought me several each January.

On the Arkansas Grand Prairie, I have often come across trails forming tunnels which often continue for many feet beneath the matted vegetation of a ditch bank. These trails appear to have been made by some mammal, yet many tell-tale signs, particularly the characteristic regurgitated pellets and roundish droppings about the size of a silver dollar, are proof that King Rails use them. Regardless of whether these trails are made by rails, mink (*Mustela vison*), rabbits (*Sylvilagus floridanus*), or rats (unidentified), trapping indicates that they are used by all four species. King Rails also spend the winter in small marshy tracts along the bayous that dissect the Grand Prairie.

At Stuttgart, Ark., a King Rail used a long water pipe about 1½ feet in diameter and running from a pumphouse to a small reservoir as its winter retreat. From late November to mid-December, I stopped by almost daily to see its fresh tracks leading from the pipe to the mudflat of the reservoir.

A rather surprising wintering habitat is the cutover longleaf pine (*Pinus palustris*) land of central Louisiana. Bobwhite and Woodcock hunters flush King Rails from little damp spots or seepage areas in the bluestem (*Andropogon tener* and *A. divergens*) range. Crayfish, a prime food of the rail, also are found there.

FLORIDA

A. H. Howell (1932, p. 202), in commenting on the status of the King Rail in Florida during the early 1930's, said it was probably most numerous in the Everglades and big marshes of the upper St. Johns River. D. J. Nicholson of Orlando (personal communication, 1962), who has made an intensive study of Florida birds since 1900, told me the King Rail is still a common to abundant breeding bird in many parts of central and southern Florida, although extensive drainage projects in the area have destroyed thousands of acres of marsh habitat. In addition to the two areas mentioned by Howell, Nicholson included the open wetlands of the Kissimmee Prairie as an important King Rail area. He added that the King Rail is common in the St. Johns River marshes in Seminole, Orange, Volusia, Brevard, and Indian River Counties; and is found in good numbers nesting on Merritt Island, Brevard County, "both in the salt marshes near Wayne's Clapper Rail, as well as in numerous fresh water ponds on that island."

S. A. Grimes (personal communication) reports that, in northern Florida, the King Rail occurs in most of the fresh-water marshes of Duvall County. Two of the several nests he found were in open cypress bayheads.

A. D. Cruickshank (personal communication), in writing from Brevard County, said that the King Rail is decidedly more common there in winter than during the breeding season, with peak numbers usually coming in late December and January. Apparently the local population is augmented by migratory populations from north of Florida. Evidence of local abundance in this area is based on the annual Audubon Society Christmas bird count conducted within a 15-mile radius of Cocoa, Fla. (Cruickshank et al., 1953–66). The numbers of King Rails reported has ranged between 11 and 93 over the past 14 years and averaged 40 per year. Cruickshank reports that the best localities are (*a*) fresh-water marshes around Lake Poinsett, a large lake in the St. Johns River, and (*b*) fresh-water marshes on Merritt Island.

During the period May 4–8, 1964, I examined some marshes in Indian River, Osceola, and Glades Counties. Approximately 10 miles south of Fellsmere, Indian River County, at the junction of State

Highways 60 and 512, I found King Rails common where maidencane and pickerelweed formed a high percentage of the vegetation of the wetter marshes (fig. 10). Apple snails (*Pomacea paludosa*), the major food of the Limpkin (*Aramus guarauna*), and the eggs of these snails, were scattered abundantly throughout the wetter marshes, but were absent from the drier ones. Houses of the round-tailed muskrat (*Neofiber alleni*) were abundant in both wetter and drier marshes. Limpkins and rails use the tops of these houses as their "dinner tables." King Rails were most commonly in the drier marshes. I estimated a density of approximately 30 birds per hundred acres in a tract on the east side of Highway 512 (table 3).

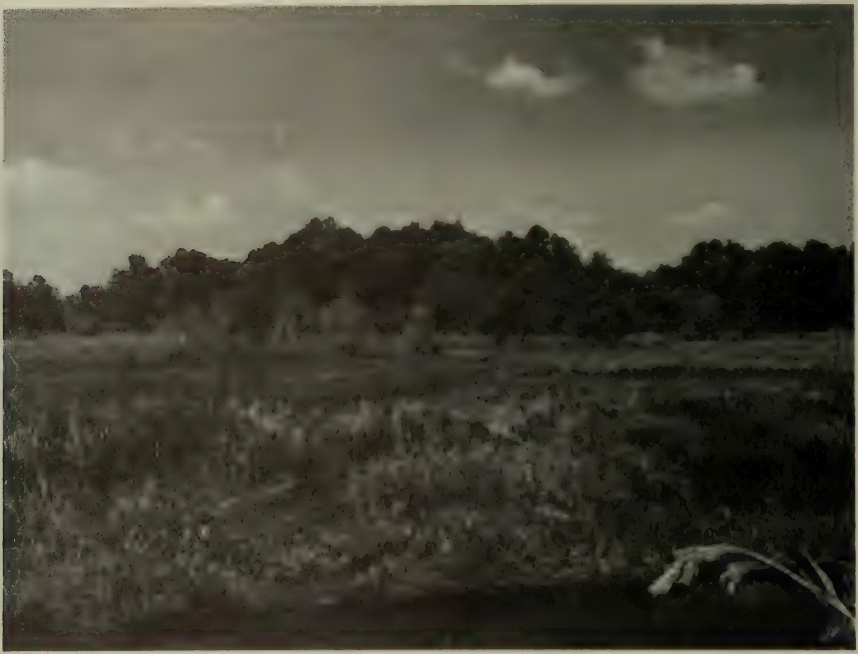

FIGURE 10.—Habitat of King Rail, 10 miles south of Fellsmere, Indian River County, Fla., April 1967. Marsh vegetation in foreground is mostly maidencane (*Panicum hemitomon*) and pickerelweed (*Pontederia cordata*), in background sawgrass (*Cladium jamaicense*). White waterlily (*Nymphaea odorata*) in pond left of center. Forest community is pond cypress (*Taxodium ascendens*). The density of King Rails in this area was estimated at 30 birds per hundred acres.

On the Brighton Seminole Indian Reservation, Glades County, I heard and saw King Rails in marshes composed largely of pickerelweed, bull tongue (*Sagittaria lancifolia*), and dotted smartweed (fig. 11). While on a trip through the reservation in January 1958, I saw two very dark-plumaged King Rails in a small pickerelweed marsh.

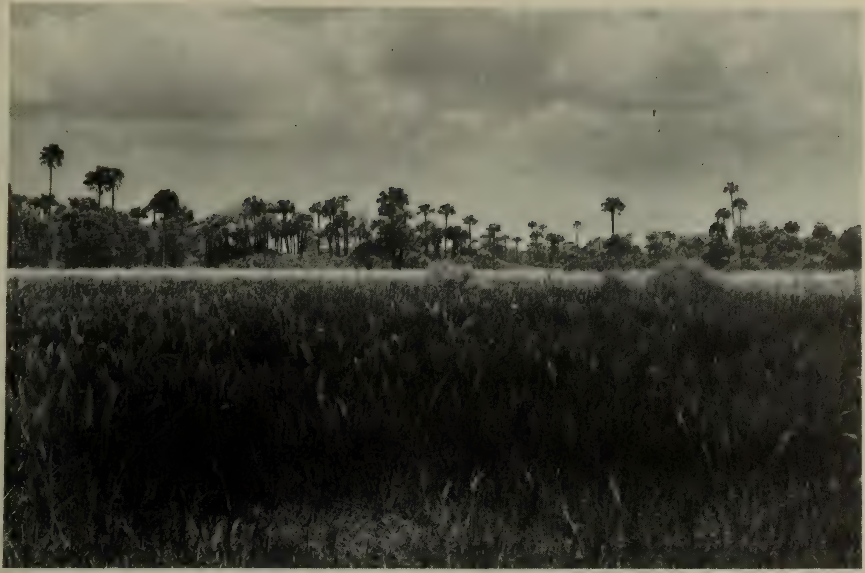

FIGURE 11.—King Rail habitat on Seminole Indian Reservation, Glades County, Fla., May 5, 1964. Predominant plants in marsh are bull tongue (*Sagittaria lancifolia*), pickerelweed (*Pontederia cordata*), and dotted smartweed (*Polygonum punctatum*).

SOUTH CAROLINA LOW COUNTRY

King Rails are common to abundant in many fresh-water and brackish tidal-river marshes of the South Carolina Low Country. These marshes are along the famous rice rivers of colonial times: the Ashepoo, Black, Combahee, Edisto, Pee Dee, Santee, Savannah, Waccamaw, Wando, and others. It was in such marshes that domestic rice was grown until about 1915. Remnants of the old ricefield dikes and canals built by slaves are still evident in the marshes (fig. 12).

The dominant vegetation type of most sections of the marshes today is giant cutgrass. Because of the blanched appearance of the giant cutgrass in winter, these marshes were referred to by the early explorer-naturalists as the "white marsh." Giant cutgrass provides excellent escape and nesting cover for rails but apparently is of no food value to them, although Purple Gallinules, Red-winged Blackbirds, and Bobolinks (*Dolichonyx oryzivorus*) feed on its flowers and seeds.

A survey of the marshland in the Low Country from the lower Cape Fear River at Wilmington, N.C., to the Altamaha River at Darien, Ga., seems to indicate that the King Rail is largely associated with the "white marsh" zone of these coastal rivers. It should be emphasized, however, that many secondary plant communities occur within this zone with varying King Rail population densities depending upon local ecological conditions.

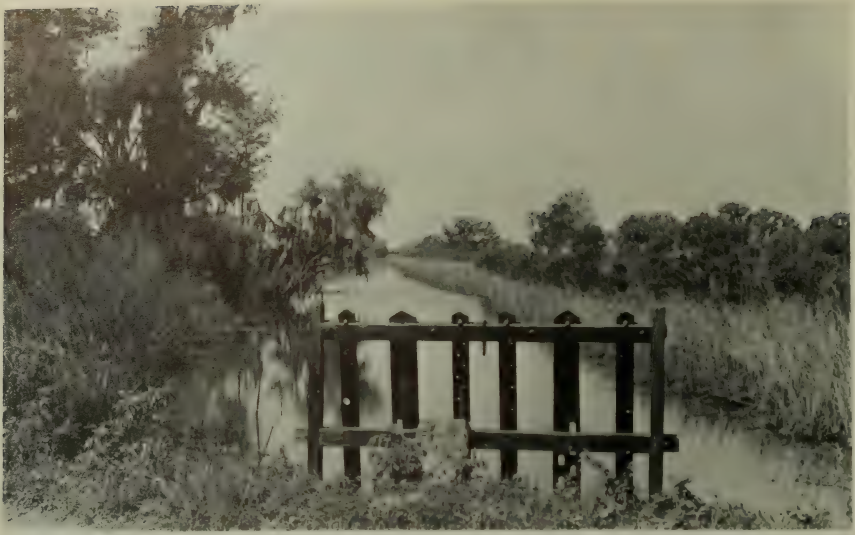

FIGURE 12.—Floodgate and ricefield canal near Savannah, Ga., April 1960. The land is irrigated as the tide rises from the Savannah River. King Rails nest in giant cutgrass (*Zizaniopsis miliacea*) seen along right-hand edge of canal. The high population density in this area is probably due to good nesting cover and the abundance of the red-jointed fiddler crab (*Uca minax*), a favorite food of the rail.

In the Low Country, March and April appear to be the best months for censusing, as King Rails are more vociferous at this time than during any other period of the year. A narrow strip of marshland bordering a river is the most suitable place for censusing.

The marshland on the west side of the Pee Dee River and one of its tributaries, the Black River, for a distance of 8 miles north of Georgetown, S.C., totalling 3,000 acres, was selected as a sampling area. The sampling design was suggested by Dr. Don W. Hayne of the Institute of Statistics, North Carolina State College, Raleigh, N.C.

Georgetown is approximately 8 miles inland from the coast on Winyah Bay at the confluence of the Pee Dee and Waccamaw Rivers. The Black River flows into the Pee Dee about 2½ miles north of Georgetown. The mean tidal range at Georgetown is 3½ feet. At Georgetown the river is slightly brackish, and big cordgrass (*Spartina cynosuroides*) is an important plant component of the marsh, especially along old ricefield canals. Six 10-acre plots were composed mainly of the following plants: big cordgrass, 35 percent; Olney's three-square, 20 percent; cattail, 14 percent; giant cutgrass, 13 percent; arrow-arum (*Peltandra virginica*), 11 percent; softstem bulrush, 5 percent; and river bulrush (*Scirpus fluviatilis*), 2 percent.

Vegetation analyses were made also of three 10-acre plots 8 miles north of Georgetown on the Black River. On the Black River, giant cutgrass formed 52 percent of the marsh vegetation, arrow-arum 36 percent, and cattail 12 percent.

For the actual census, the entire marsh area, as shown on U.S. Geological Survey maps, was blocked off into 64 primary sampling units, each a 630-foot-wide transect extending from the edge of the river to the land. Each transect was divided into 10-acre plots, the number in a transect depending upon the width of the marsh at that location along the river.

Ten of the 64 transects were randomly selected as primary sampling units, and one 10-acre plot from each was chosen for censusing. At least 1 hour between 5 and 8 a.m. or 5 and 7 p.m. during the period April 10 through 12, 1961, was spent in each plot counting calls.

The number of male King Rails in a transect was estimated by multiplying the number of 10-acre plots in that transect by the number of birds heard in the census plot. The estimated total of 755 males in the 3,000-acre marsh was derived by multiplying the average number of birds per sample transect by the total number of transects. The density estimate of 25.2 male birds per 100 acres was calculated by dividing the total population by 30 (the number of 100-acre units in the 3,000-acre marsh). Since some of the calling King Rails were undoubtedly already mated, and most of the others would be eventually, the average number of breeding rails per 100 acres could be inferred to be 25 pairs (table 3).

Sampling indicated that the density of the King Rail population was higher at Georgetown in the Pee Dee River marshes than several miles up river along its tributary, the Black River. One 10-acre plot at Georgetown had six calling rails, and four other plots had four each. None of the Black River plots had more than two rails. The higher density at Georgetown could be attributed to the higher proportion of red-jointed fiddler crabs (*Uca minax*).

Savannah National Wildlife Refuge

The Savannah National Wildlife Refuge in South Carolina and Georgia, near Savannah, is about 25 miles upriver from the ocean on what was formerly a rice plantation (fig. 13) and is divided by the Savannah River. The larger acreage is on the South Carolina side. Its marsh is the fresh tidal type, with a tide which rises about 1 foot.

Giant cutgrass is the dominant vegetation of much of the marsh on the refuge. The old growth of cutgrass forms a nearly pure stand, and has an average height of about 5 feet, but will average higher when the new growth matures. Arrow-arum, dotted smartweed, and swamp smartweed (*Polygonum hydropiperoides*) are scattered about the marsh, particularly along the edges and on high spots. There are numerous small holes made by the red-jointed fiddler crab, an important food of the King Rail, along the tidal creeks and edges of the marsh. While making a survey of King Rail populations in April

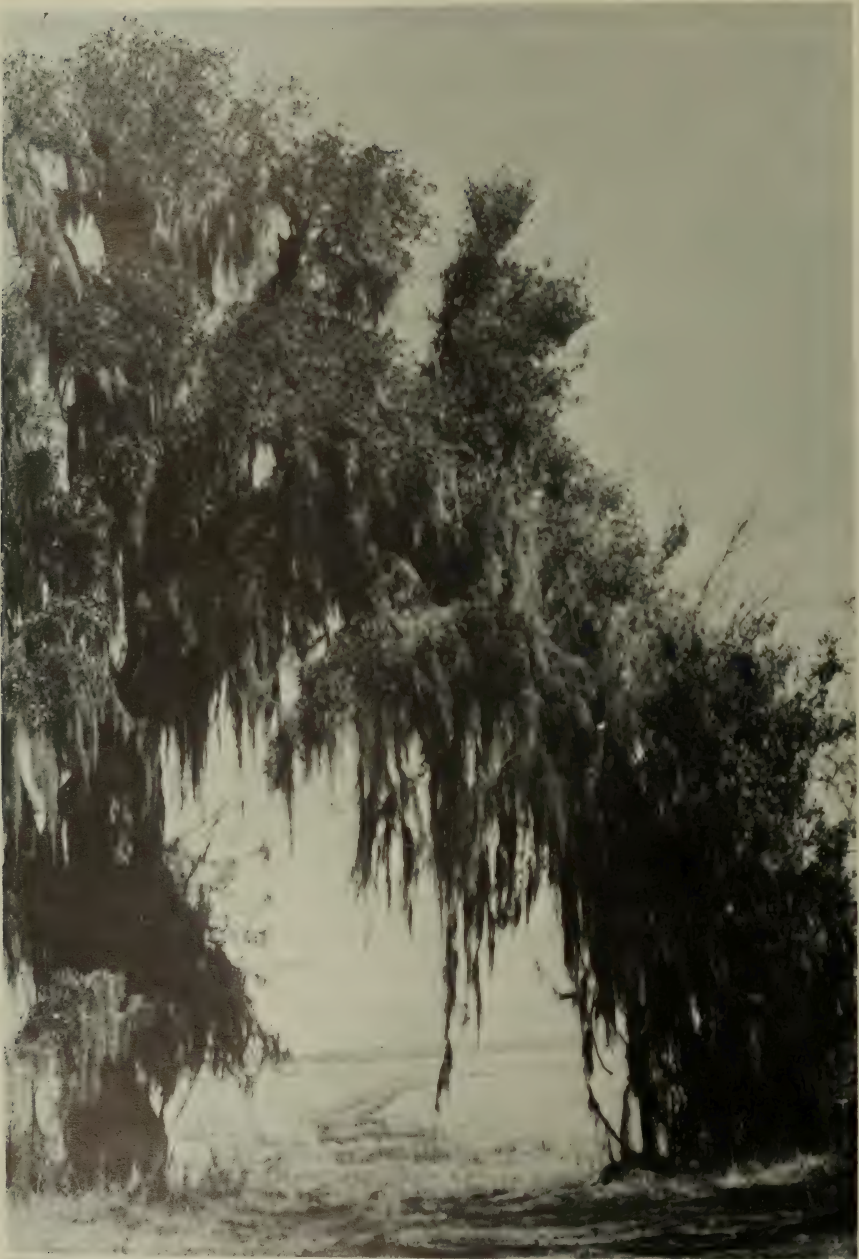

FIGURE 13.—South Carolina Low Country: ricefield nesting habitat in Jasper County along the Savannah River, fall 1958.

1960, I estimated a density of one pair per acre in the cutgrass marsh bordering the river. A year later I also heard many King, Virginia, and Sora Rails calling at night in the same marsh.

Much of the refuge canal system and some of the ponds are choked with alligatorweed, a plant that forms extensive mats upon which rails, gallinules, coots, herons, and several species of ducks do much of their foraging for aquatic insects (fig. 14). Small patches of giant cutgrass in which Purple Gallinules nest are sparsely distributed along the canals. I located many King Rail pairs with feeding territories along sections of the canals. Some of these territories were not more than 20 feet square, indicating the high food productivity of these aquatic mats. All of the King Rails that I observed feeding in the choked-up canals, however, nested on the other side of the dike in a deep-water impounded marsh containing a mixture of giant cutgrass, sawgrass, cattail, royal fern (*Osmunda regalis*), buttonbush (*Cephalanthus occidentalis*), and myrtle (*Myrica cerifera*).

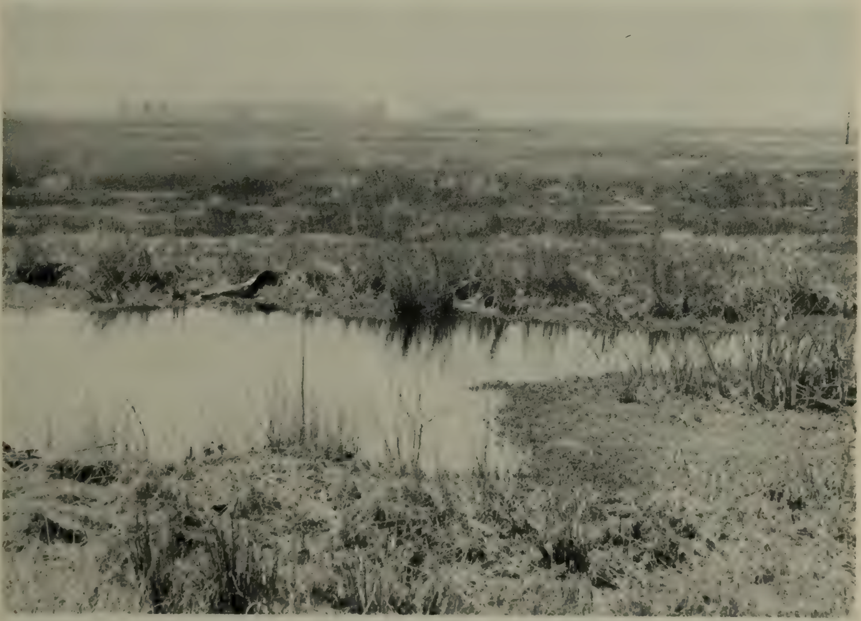

FIGURE 14.—Alligatorweed (*Alternanthera philoxeroides*) in canal at Savannah National Wildlife Refuge, Jasper County, S.C., April 1960. This plant forms spongy, extensive mats upon which rails, gallinules, coots, herons, and ducks forage for aquatic insects, fish, amphibians, and crustaceans. Such mats have an obvious value to birds that utilize its growth form to facilitate their quest for food. Note alligator on far side of canal. Alligators feed on many forms of animal life including various water-birds such as rails.

I made a roadside count of calling males on April 12, 1960, along a 7-mile route beginning at the north entrance to the refuge on U.S.

Highway 17, continuing along the east dike, through the string of island hammocks, and ending at the Savannah River just inside the south entrance on U.S. Highway 17. On this census, made between 6 and 7 p.m., 46 males were tallied (table 3).

On April 20, 1961, I estimated the breeding King Rail population in a nearly pure softstem bulrush (*Scirpus validus*) marsh along U.S. Highway 17A, about 2 miles north of Savannah, Ga. The bulrush averaged about 5 feet in height, and the marsh had a firm bottom covered with 1 to 2 inches of water. A 13-acre section was marked off into transects, and King Rail territories were then spot-mapped on the basis of three calls from any one area. This mating-call count indicated a breeding population of 14 males in the 13-acre tract (table 3).

Upper Savannah River Valley

King Rails also nest further upriver in the Savannah River Valley section of the Upper Coastal Plain in South Carolina. Norris (1963, p. 2, 19) described the typical nesting habitat as a "Carolina bay"—an oval-shaped water-filled depression with rank growths of maidencane and other aquatic plants.

CHESAPEAKE BAY COUNTRY

Tidewater Virginia

Tidewater Virginia is the section of the Middle Atlantic Coastal Plain that extends from the fall line (the line separating the Piedmont Plateau from the Coastal Plain) to the Chesapeake Bay. It is dissected by numerous rivers, the largest of which are the Potomac, the Rappahannock, the York, and the James.

The King Rail is common throughout the year in much of Tidewater Virginia and usually occurs in greatest numbers in marshes where big cordgrass is dominant. Big cordgrass is one of the best cover plants for King Rails in Tidewater because of its height and occurrence in fairly dense stands, and because it retains its life form throughout most of the year (fig. 15). In the early 1960's, I found King Rails common in the big cordgrass marshes at Norfolk, West Point, and Tappahannock.

Other marsh types, especially Olney's three-square, wild rice (*Zizania aquatica*), and cattail, are important for the King Rail, but there is less acreage of these types, and wild rice does not provide cover in the winter. During the winters of 1958 and 1961, I encountered several muskrat trappers who were inadvertently catching King Rails in the extensive Rappahannock River brackish marsh flats across the river from Tappahannock. These flats are dominated by Olney's three-square (fig. 16). Several King Rails were removed from muskrat

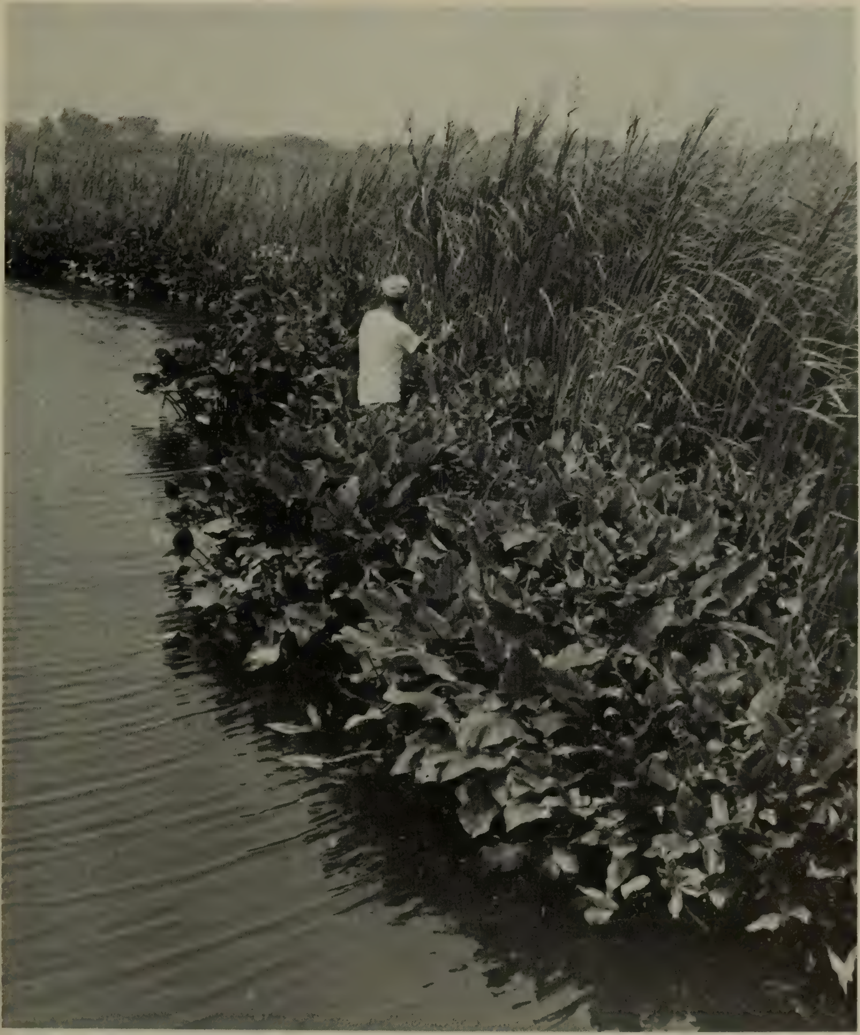

FIGURE 15.—Big cordgrass (*Spartina cynosuroides*) (tall plant) and arrow-arum (*Peltandra virginica*) (broad-leaved plant next to water) along tidal creek, Nanticoke River marsh, Wicomico County, Md., August 1967. Big cordgrass usually grows along the margins of tidal guts in brackish bay marshes, but may form extensive, nearly pure stands in brackish tidal-river mashes. It is one of the most important cover types for King Rails in the Chesapeake Bay region. (Photograph by Luther Goldman.)

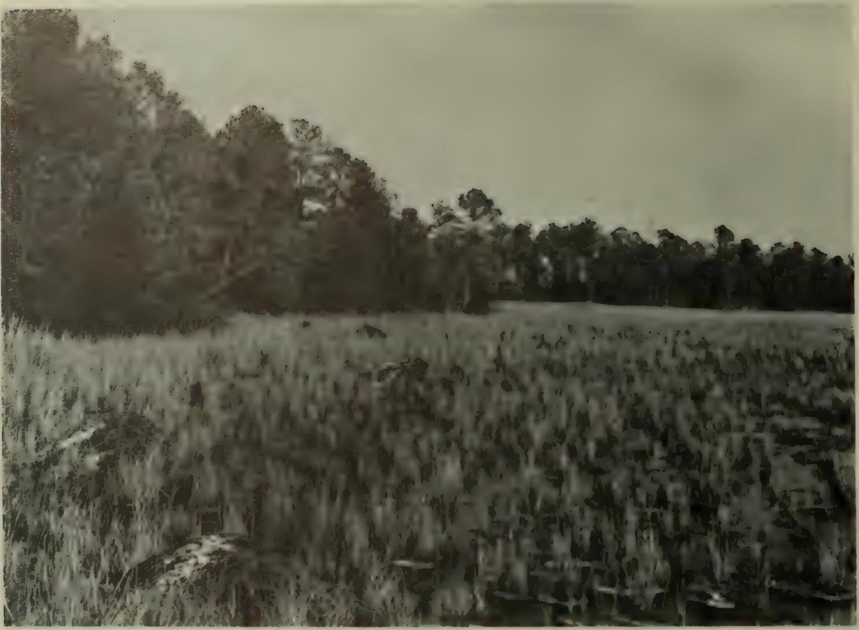

FIGURE 16.—Winter abode of King Rail. Rappahannock River near Tappahannock, Va., January 1961. Vegetation is mainly Olney's three-square (*Scirpus olneyi*) and saltmarsh cordgrass (*Spartina alterniflora*).

traps as I watched a trapper run his line. In these and other tide-marsh habitats, tidal action along the creeks and over adjacent marshlands keeps the water open throughout much of the winter.

At Hog Island, Surry County, in the James River opposite historic Jamestown, C. C. Steirly found both King and Clapper Rails breeding. Steirly (1959, p. 47–48) made the following comments about the rail habitat on the island:

> Apparently there is a salinity gradient between the east side of the refuge and the west side of Cobham Bay. Hog Point might be the dividing line. There seems to be a slight difference in the tidal vegetation between the two sides of the refuge although the cord grass marsh seems to be the dominant feature along the east or down river side. The King Rail is most often seen on the west side; however, there is as yet no proof that it does not breed on the east side. In one of the particular haunts of the King Rail, pickerel weed (*Pontederia cordata*) and bulrush (*Scripus robustus*) occur in some abundance where there is less tidal fluctuation.

Virginia Eastern Shore

The Eastern Shore peninsula of Virginia lies between Chesapeake Bay and the Atlantic Ocean. While King Rails would be expected to occur on the bay side of the peninsula, their presence on the offshore barrier islands on the ocean side would seem rather surprising; nevertheless, on these salty coastal islands King Rails are found in land-locked fresh-water marshes. Montagna and Wimsatt (1942, p. 434–436) collected a female on Rogue Island 11 miles off the coast between Hog and Cobb Islands. The specimen had a fully developed swollen brood patch, and its oviduct contained an egg with shell.

There are several records from Chincoteague Island. Robert E. Stewart encountered paired adult King and Clapper Rails with a brood in a salt meadow cordgrass marsh on this coastal island. The Chincoteague salt marshes are one of the important Clapper Rail hunting grounds along the Atlantic Coast, and King Rails occasionally turn up in hunters' bags.

One of the best King Rail areas on the bay side of the eastern shore peninsula is Bullbegger Creek, a tributary of the Pocomoke River. Big cordgrass is the dominant plant in this creek marsh.

At Knott's Island, at the head of Currituck Sound, partly in Virginia and partly in North Carolina, A. J. Duvall (1937, p. 462) and party collected a female King Rail and five chicks along a roadway in a salt marsh on June 1, 1936.

Maryland Eastern Shore

In Maryland the King Rail is mainly associated with tidal marshes of the Chesapeake Bay system, and is found in greatest numbers in the extensive brackish tidal-river marshes of the Eastern Shore, especially in the vast area of fresh and brackish bay marshes of Dorchester County (see R. E. Stewart, 1962, for a description of Maryland Chesapeake Bay marsh communities). In this area, the following plants are usually present as pure stands or are found in some combination in areas where King Rails occur: big cordgrass, broad-leaf and narrow-leaf cattail (*Typha latifolia* and *T. angustifolia*), Olney's three-square, switchgrass (*Panicum virgatum*), softrush, and rosemallow (*Hibiscus moscheutos*).

The importance of big cordgrass in the Maryland section of the Chesapeake Bay is comparable to that in Tidewater Virginia.

In the brackish tidal-river marsh community of the Choptank River at Dover Bridge between Talbot and Caroline Counties, a muskrat trapper caught 50 King Rails in a single season (January 1 to March 15). Most of the birds were caught where big cordgrass was dominant but usually mixed with Olney's three-square and switchgrass. Because of the sparseness of winter marsh cover, King Rails often seek means of escape and places for hiding different from those used during the rest of the year. A muskrat trapper on the Choptank River in Maryland reports that whenever he surprises a rail along a tidal gut in the marsh it almost invariably darts into a muskrat hole along an embankment.

Robert E. Stewart has observed both King and Clapper Rails in the same big cordgrass marsh along Ape Hole Creek in Somerset County.

Both species are common there, probably because of the abundance of such prime rail foods as blue crabs (*Callinectes sapidus*), mud crabs (*Sesarma reticulatum*), red-jointed fiddler crabs, periwinkle snails (*Littorina irrorata*), and salt-marsh snails (*Malampus lineatus*).

In a brackish bay marsh community at Elliott Island, Dorchester County, on May 28, 1959, I heard King Rails calling between 11 p.m. and midnight. Most were calling from the narrow band of big cordgrass that characteristically borders the sides of Pokata Creek. Soras, Virginias, and Black Rails (*Laterallus jamaicensis*) were heard at the same time and in the same general area, but mostly in a salt-meadow marsh type community.

In a fresh bay marsh community north of Savannah Lake, Elliott Island, King Rails occur where the switchgrass marsh extends inland for a mile or so forming an understory beneath a loblolly pine (*Pinus taeda*) forest (fig. 17). It seems rather strange to flush a King Rail from beneath a stand of loblolly pine. The Short-billed Marsh Wren was found nesting and wintering in this same pine-switchgrass association. Switchgrass, which attains a height of 5 feet, retains its life form throughout the year, thus affording excellent cover, especially in winter when several other marsh plants have deteriorated.

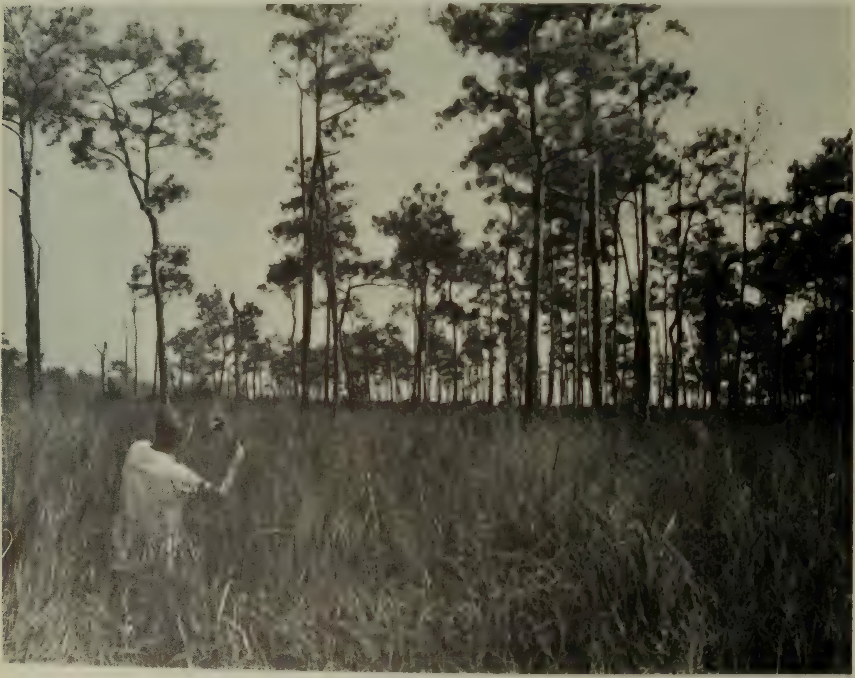

FIGURE 17.—Habitat of King Rail in loblolly pine (*Pinus taeda*) and switchgrass (*Panicum virgatum*) association, Elliott Island, Dorchester County, Md., August 1967. (Photograph by Luther Goldman.)

On June 10, 1965, I made a King Rail survey of a section of the Nanticoke River marshes, Wicomico County, across the river from the town of Vienna. This was a typical muskrat marsh in which Olney's three-square was dominant, with rosemallow scattered throughout. Four King Rail nests, located at the bases of rosemallow plants, were found in a 20-acre section of the marsh. The life form of this plant, with its cradle-like base and broad leaves forming a protective cover above, makes it well suited for nest cover (fig. 18).

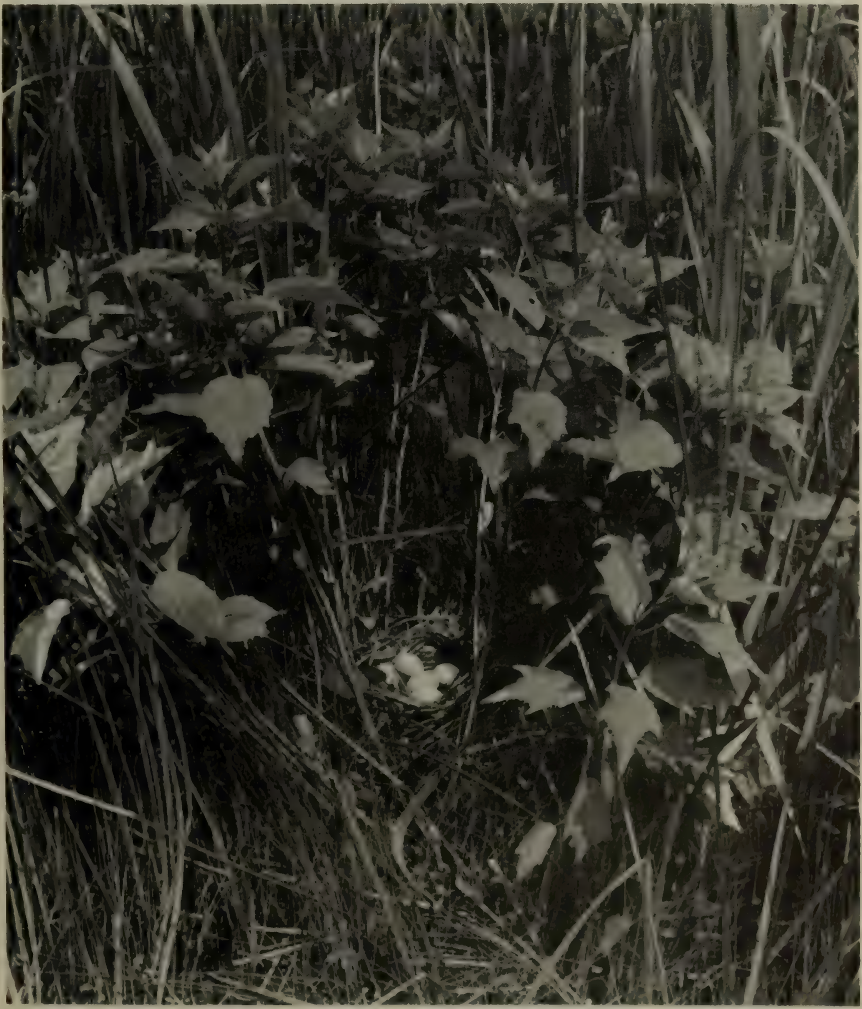

FIGURE 18.—Nest and eggs of King Rail in Nanticoke River marsh, Vienna, Wicomico County, Md., June 10, 1965. Nest found in section of marsh dominated by Olney's three-square (*Scirpus olneyi*) interspersed with rose mallow (*Hibiscus moscheutos*). Four nests found in this marsh were all in rose mallow. Because of the life form of this plant, the rail does not have to build a canopy over its nest as it does when using other plants.

In May 1959, while censusing Red-winged Blackbirds on a number of small islands in Chesapeake Bay, I was surprised to find King Rails on almost all of them. The islands provide a brackish environment. On Long Marsh Island, May 26, 1959, I observed a nest constructed mostly of saltmeadow cordgrass and containing nine eggs (fig. 19).

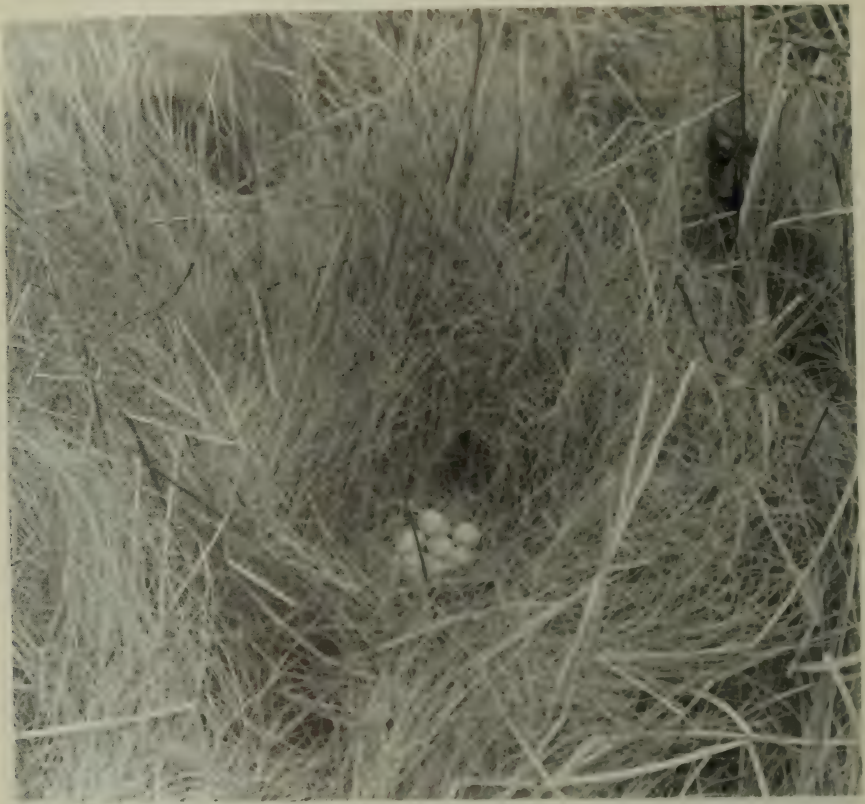

FIGURE 19.—Nest and nine eggs of King Rail in brackish marsh, Long Marsh Island, Eastern Bay (of Chesapeake Bay), Queen Annes County, Md., May 26, 1959. Nest constructed of saltmeadow cordgrass (*Spartina patens*) and Olney's three-square (*Scirpus olneyi*).

Small patches of saltmeadow cordgrass were scattered throughout the dense growth of hightide-bush (*Iva frutescens*) on the island. The King Rail nest was only 15 feet from a Black Duck (*Anas rubripes*) nest. On another Chesapeake Bay island (Miller's Island) a King nest was found in a pure stand of saltmarsh cordgrass.

Inner Coastal Plain of Maryland

Four pairs of King Rails nested in 10 acres of shrub swamp–marsh mixture at the Patuxent Wildlife Research Center, near Laurel, Md., during May and June 1965. Softrush, tussock sedge (*Carex stricta*), and arrowhead (*Sagittaria* sp.) were the common emergent herbaceous plants. Woody marsh plants included swamp viburnum (*Viburnum nudum*), arrow-wood (*V. dentatum*), buttonbush, alder (*Alnus serrulata*), winterberry (*Ilex verticillata*), red maple (*Acer rubrum*), and willow (*Salix nigra*). In late summer Woodcock (*Philohela minor*) were common in this same area.

DELAWARE BAY, DEL.

King and Clapper Rails inhabit the extensive brackish bay marshes known as Broadway Meadows between Fleming's Landing and Woodland Beach, Kent County, Del. Two King-Clapper pairs and their nests were found in June 1960 at Taylor's Gut approximately halfway between Fleming's Landing and Woodland Beach (fig. 20).

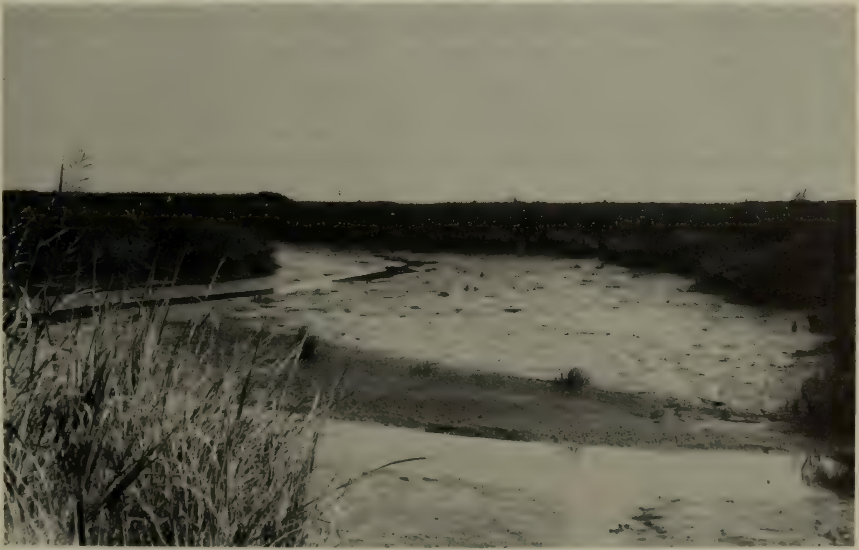

FIGURE 20.—Taylor's Gut at low tide, Kent County, Del., September 30, 1963. Vegetation in this breeding habitat of mixed King and Clapper Rail populations is mainly saltmarsh cordgrass (*Spartina alterniflora*), big cordgrass (*Spartina cynosuroides*), saltmarsh bulrush (*Scirpus robustus*), and hightide-bush (*Iva frutescens*). (Photograph by Frederick C. Schmid.)

The section of marsh at Taylor's Gut where mixed populations occur is more typical of Clapper Rail than of King Rail habitat. The dominant vegetation types are saltmarsh cordgrass and saltmarsh bulrush (table 4). Hightide-bush borders the tidal guts.

TABLE 4.—*Plant composition at three stations in Broadway Meadows, Del., in 1960*

[In percent, based on estimates for five 10-foot-square quadrats at each station; tr. = trace]

	Fleming's Landing (King Rails only)	Taylor's Gut (Intermediate area; King and Clapper Rails)	Woodland Beach Causeway (Clapper Rails only)
Saltmeadow cordgrass	50	tr.	
Saltmarsh cordgrass	15	50	70
Saltmarsh bulrush		30	20
Big cordgrass	5	10	10
Olney's three-square	25		
Hightide-bush	5	10	
Saltgrass	tr.	tr.	
Groundsel-bush	tr.		

Two miles inland at Fleming's Landing only King Rails were observed. The vegetation at Fleming's Landing is composed mostly of saltmeadow cordgrass and saltgrass (*Distichlis spicata*). Occasional patches of Olney's three-square, big cordgrass, and saltmarsh cordgrass were distributed through the saltmeadow marsh, and as in the intermediate area at Taylor's Gut, hightide-bush bordered some of the tidal guts.

Two miles further toward Delaware Bay along the Woodland Beach Causeway, Clapper Rails were abundant, but King Rails were not observed. Saltmarsh cordgrass and saltmarsh bulrush were the dominant plants at this station. Hightide-bush was not present.

It is interesting to note that in the Taylor's Gut area salinity readings are intermediate between those at the other stations (table 5).

TABLE 5.—*Salinity determinations at three stations in Broadway Meadows, Del. in 1960*

[In parts per million. Water samples were analyzed in the chemistry laboratory, Patuxent Wildlife Research Center, Laurel, Md.; sea strength is 32,000 to 35,000 p.p.m.]

	Fleming's Landing	Taylor's Gut	Woodland Beach Causeway
Low tide	4,380	7,190	7,600
High tide	3,700	5,670	7,480

The red-jointed fiddler crab was abundant at Taylor's Gut during the period 1959 through 1963, and formed the main food of the rails. There was a marked diminution in the fiddler crab population in 1964, and a corresponding decrease in the rail population.

Other breeding birds at Taylor's Gut in order of relative abundance are the Long-billed Marsh Wren, Red-winged Blackbird, Song Sparrow (*Melospiza melodia*), Seaside Sparrow (*Ammospiza maritima*), Swamp Sparrow (*Melospiza georgiana*), Black Duck, and Least Bittern. The muskrat, raccoon (*Procyon lotor*), and rice rat (*Oryzomys palustris*) are common mammals in the area.

GREAT LAKES REGION

In Lake County, Ill., Beecher (1942, p. 13–14) found the *Carex lacustris* consocies or lake sedge–marsh wren community to be the optimum breeding habitat of the King Rail. Three nests were located in 5.39 acres (Beecher, 1942, p. 29). Beecher characterizes this marsh type as follows:

> Although the *Typha* consocies is so distinctive in its characteristics, there is considerable overflow of the species presumably finding their optimum within its bounds into the lake sedge which usually adjoins it in shallower water. *Carex lacustris* tends to exist as a closed community; it is more completely dominant in its own zone and its boundaries more sharply marked out than those of any other plant in the hydrosere. To state that it has the same lifeform as *Typha* means nothing, since, though much coarser than the grass-like sedges which follow it, the stalk offers little support. Nests of bittern, gallinule and blackbird are decidedly less frequent than in cattails, those of the redwing being constructed on a stool, generally. But the King and Sora Rails and the Prairie Marsh Wren are much more abundant in this sedge than in cattails, suggesting that it has qualities of its own. Primarily, it offers the tussock or stool type of substrate so attractive to rails, and anyone viewing this community for the first time would appreciate its fitness for the wrens. The growth is denser, less erect and, doubtless, easier to work.

The King Rail also formerly occurred commonly in the extensive cattail marshes of the southwestern shore of Lake Erie. On May 30, 1931, Milton Trautman (personal communication) recorded 18 King Rails in 1 hour in these marshes. Trautman further stated that in the Sandusky Bay region, on many June and July evenings during the years between 1925 and 1934, he saw from one to eight broods on roads adjacent to marshes. At Buckeye Lake in east-central Ohio, Trautman (1940, p. 229–230) reported more than 50 pairs nesting annually between 1922 and 1930. Trautman told me that by 1959 only two or three pairs nested there. Surveys in 1961 by Trautman and others to determine the status of the King Rail in Ohio revealed that it was disappearing at an alarming rate.

In Ontario, Baillie (1940, p. 109) reported five breeding localities (based on the presence of nests or broods) along the southern edge of Ontario from Lake St. Clair to Toronto: St. Anne's Island, Lake St. Clair, Lambton County, May 1882 (nest of 13 eggs); eastern end of the north shore of Lake Erie, at Point Abino, Welland County, May 30, 1894 (nest of 10 eggs); north shore of Lake Erie, at Long Point, Norfolk County, summer of 1921 and 1926 (young); western end of the north shore of Lake Ontario at Toronto, August 22, 1938 (young); and at Hamilton, August 6, 1939 (young).

NORTH-CENTRAL PRAIRIE MARSHES

Tanner and Hendrickson (1956, p. 54–56) studied the King Rail in the marshes of Dewey's Pasture Public Shooting Ground, Clay County, Iowa, from April 1951 to April 1953. Their description of the habitat in this area is as follows:

> The 402-acre research area included 28 marshes lying in the hollows between gently sloping prairie knolls. These marshes ranged in depth from several inches to 4 feet and in area from 0.2 acres to 18.0 acres. Of the total 96.4 acres of marsh, 81.4 acres supported emergent vegetation habitable by rails. The remaining 15.0 acres consisted of open water. The predominant species of emergent vegetation in the shallowest water along the shores were blue-joint grass [*Calamagrostis canadensis*], prairie cordgrass [*Spartina pectinata*], tussock sedge and fox sedge [*Carex vulpinoidea*]. In waters of intermediate depth the most abundant species of emergent plants were river grass [*Fluminea festucacea*], lake sedge, sweet flag [*Acorus calamus*] and water smartweed [*Polygonum coccineum*]. In deeper waters the predominant species were broad-leaved cat-tail, narrow-leaved cat-tail, river bulrush [*Scirpus fluviatilis*], hard-stemmed bulrush [*Scirpus acutus*], pale great bulrush [*Scirpus heterochaetus*] and large bur-reed [*Sparganium eurycarpum*]. The plant names follow Hayden (1943), . . .
> · . . . Four of the six nests were found in areas of marsh in which lake sedge was the predominant vegetation, while the others were found in pure stands of river bulrush and were attached to plants of that species. Of the four nests located in the lake sedge cover-type, only one was actually attached to plants of that species. The others were supported by tussocks of blue-joint grass or cordgrass, or clumps of hard-stemmed bulrush, which occurred here and there among the lake sedge.

The estimated number of breeding adults in the 81.4 acres of marsh was 12. In the same area there was an estimated adult breeding population of 54 Virginia Rails and 52 Soras.

NORTHERN GREAT PLAINS

The King Rail rarely breeds in the northern Great Plains, but R. E. Stewart (personal communication) located a breeding pair in a prairie pothole in the Missouri Coteau of western Dickey County, N. Dak., in June 1961. This pothole was a fresh-water type and was composed chiefly of whitetop grass (*Fluminea festucacea*) and slough sedge (*Carex atherodes*), with an outer border of river bulrush. Several pairs of Virginia Rails and Soras were also observed in this same pothole. Stewart also recorded single King Rails on June 5 and 24, 1963, about 12 miles west of Buchanan, Stutsman County, N. Dak., where common cattail and common spikerush were the dominant plants.

Description

SIZE

The male King Rail is generally larger and heavier than the female. Males in my study weighed about 100 grams more than females. Six of nine adult males weighed over 400 grams each, and the average of all nine was 415.4 grams, whereas the average of nine females was 306.0 grams. These weights do not differ greatly from those of Clapper Rails (table 6).

Measurements of body length and wing length also reflect the difference in size of the sexes. These are compared in table 7 along with measurements of the Clapper Rail, which is somewhat smaller in these dimensions.

ADULT PLUMAGE

There are no apparent differences between the plumages of the male and the female King Rail. Ridgway and Friedmann (1941, p. 83) described the plumage as follows:

> Forehead, crown, occiput, and nape deep, rich mummy brown, the feathers of the forehead and crown with shiny black shafts; scapulars, interscapulars, upper and lower back, rump, upper tail coverts, and rectrices deep fuscous to fuscous-black, the feathers broadly edged with tawny-olive to buckthorn brown, the edges becoming broader on the more posterior parts, often occupying (between the two margins) more than half the width of the feather on the long scapulars and the feathers of the rump and the upper tail coverts, narrow on the anterior interscapulars; upper wing coverts deep hazel to bright russet, some of the outer median and .greater coverts with narrow whitish tips and a concealed narrow subterminal whitish band; remiges sepia, the outer web of the outermost primary often slightly paler—Saccardo's umber; a light strip from the base of the maxilla over and behind the eye light pinkish cinnamon; rest of lores, circumocular area, cheeks and auriculars grayish mummy brown; lower cheeks and sides of throat cinnamon; chin and middle of upper throat white; lower throat, breast, and upper abdomen cinnamon becoming paler in the mid-ventral part of the upper abdomen, the feathers faintly tipped with white on the upper abdomen, without pale tips on the breast feathers; middle of abdomen light buff; thighs similiar but transversely barred with deep drab to hair brown; flanks sepia barred with white, the feathers tipped with white and crossed by two or three white bars each; vent similar to flanks; under tail coverts white, not buffy, and with sepia areas reduced making the white bars wider; the outer webs of the lateral ones wholly white; axillars and under wing coverts deep rich sepia tipped and crossed by narrow bars of white; . . .

Ridgeway and Friedmann described the dark and light phase adult plumages of the King Rail, and suggested that the light phase rarely occurs. My recent investigations indicate that the so-called light phase plumage is probably the result of hybridization or intergradation in areas of mixed King and Clapper Rail populations, or it may be due simply to individual variation.

In my collection I have a series of 16 King and Clapper Rail specimens taken from a 1-square-mile area of brackish marsh in Delaware (table 1). In this series there are Kings and Clappers with typical plumages and also gradations from one type to the other. Some of the specimens appear to be light phase King Rails. Ridgeway and Friedmann (1941) made no mention of locality, habitat, or the possibility of mixed populations where so-called light-phased birds were collected.

TABLE 6.—*Weights of King and Clapper Rails*

[In grams. All specimens were adults. Bottom line shows mean weights.]

King Rail (*R. e. elegans*)[1]		King Rail (*R. e. tenuirostris*)[2]		Clapper Rail (*R. l. crepitans*)[3]		Clapper Rail (*R. l.*)[4]	
Males	Females	Males	Females	Males	Females	Males	Females
339.9	253.0	271	220	332.2		300	275
366.0	272.0	306	255	335.0		325	275
367.9	305.0	317	268			300	275
421.0	313.3	331				325	275
427.0	319.0					300	275
436.0	320.0					350	275
438.3	322.0					300	250
453.0	323.0					300	
490.0	325.0					325	
						350	
						350	
						350	
						325	
415.5	305.9	306.3	247.7	333.6		320.8	271.4

[1] From Arkansas, Delaware, and Louisiana (author's data).
[2] All from Mexico (Warner and Dickerman, 1959, p. 50).
[3] Both from Delaware (author's data).
[4] All from South Carolina, each to nearest 25 grams; race (*R. l. crepitans* or *R. l. waynei*) not specified (Blandin, 1963, p. 33).

TABLE 7.—*Measurements of King and Clapper Rails*

[From Ridgway and Friedmann, 1941. All specimens were adults. All measurements are given in mm. Wing measurements are for the chord, from bend of wing to tip of longest primary]

	King Rail (*R. e. elegans*)				Clapper Rail (*R. l. crepitans*)			
	Males [1]		Females [2]		Males [3]		Females [4]	
	Range	Average	Range	Average	Range	Average	Range	Average
Wing	159.0–177.0	163.4	147.0–162.0	154.3	142.5–159.5	151.1	135.5–160.0	146.8
Tail	56.0– 72.5	65.9	60.0– 70.0	64.4	55.0– 69.0	64.6	55.0– 69.5	61.9
Exposed culmen	58.0– 65.5	62.5	50.0– 63.0	61.9	55.0– 69.5	63.3	53.5– 67.0	59.6
Tarsus	52.0– 64.0	58.4	49.5– 58.0	54.0	48.0– 56.0	51.7	41.0– 56.0	48.1
Middle toe without claw	50.5– 60.5	55.1	46.0– 56.0	50.8	45.5– 53.5	48.8	40.0– 52.0	45.9

[1] 18 specimens from Illinois, Missouri, District of Columbia, Virginia, Alabama, Louisiana, South Carolina, and Florida.
[2] 14 specimens from Illinois, District of Columbia, Maryland, Virginia, Louisiana, and Florida.
[3] 21 specimens from Massachusetts, New York, New Jersey, Virginia, and North Carolina.
[4] 17 specimens from New Jersey, Virginia, and North Carolina.

NOTE.—An incubating female (adult ?) King Rail collected at Stuttgart, Ark., May 1962, had a left wing measurement (chord) of only 141.0 mm.; a paired female (adult ?) collected at Taylor's Gut, Kent County, Del., Apr. 15, 1963, had a left wing measurement (chord) of 145.0 mm.

The most unusual plumage that I have seen was that of a very dark brown, almost blackish bird near Lake Okeechobee, Fla., January 1958. William B. Robertson (personal communication) told me of seeing several birds with similar dark plumage in the Everglades, and Luther C. Goldman collected such a specimen near Cape Sable, Fla. Dr. Harry C. Oberholser examined the specimen and remarked that it had a most unusual plumage. Apparently he did not make a critical study of it, and it has since been lost.

LEGS AND FEET

Legs and feet are pale brownish gray. An adult male collected at Welch, La., January 12, 1963, and two adult males collected in August 1963, in Delaware, had a pinkish-brown color on the inside and outside heel areas and immediately above. This heel color is apparently typical of birds in their second year or older.

BILL

In most adult birds the bill is orange-yellow from the base to at least the nares in the upper mandible, and usually slightly beyond in the lower mandible. The outer part of the bill is brownish. However, one marked wild bird known to be at least 2 years old had a lightish-brown bill more typical of immatures. A captive immature did not attain the color at the base of the bill until it was 10 months old. The color was then yollowish rather than orange-yellow. Young wild birds 2 to 3 months of age had lightish brown bills. The upper mandibles of these birds were darker.

TONGUE AND LINING OF MOUTH

Tongues and mouth linings of birds 1 year or older, examined immediately after collection, were a bright orange-red. Young birds in juvenal plumage, collected during the summer, had yellow tongues and mouth linings.

EYE

Irides of adult King Rails are reddish-orange while pupils are grayish-black. Eyes of newly hatched chicks are grayish-brown, and 1- and 2-month-old birds have dull-brown irides.

NOTES ON SEXING AND AGING

In a 50-bird sample from Louisiana, examined 3 months after collection in late fall, I was able to sex 47 of 50 birds by weight, and age 36 of 45 by color of the bill and heel. As an aging criterion, the color of the bill is used most accurately with live or freshly killed birds, because with time it fades. Wing measurements can also be used as an aid in sexing birds, since the average for males is nearly 10 millimeters greated than that for females. From late summer to at least early winter, the presence of a bursa in young birds will distinguish them from adults.

MOLTING

Adult King Rails have a complete molt and are flightless for nearly a month. Young of the year undergo a partial molt which does not include the tail and flight feathers.

In the Middle Atlantic States the molting season for King Rails extends from the beginning of the breeding season in late May until the beginning of fall migration in early October.

In this study, breeding birds found in molt during May and June were replacing only body feathers. Molt of the remiges and rectrices was not observed until the first week in July. I have not been able to ascertain the relation between the partial molt during the breeding season and the complete molt in the summer. Birds that are renewing their body feathers while nesting in May and June may be undergoing prenuptial molts or early postnuptial molts during which the wing and tail feathers are not dropped.

Bent (1926, p. 262) stated that adult King Rails undergo a partial molt of the contour plumage during early spring. Eight specimens collected in the Middle Atlantic States in March and April showed no signs of molt. An adult female King Rail in the U.S. National Museum, taken at Alligator Bluff, Kissimmee River, Fla., April 9, 1901, was molting body feathers when collected. This could well have been a breeding bird because in Florida this species begins nesting in late winter. In my records the earliest recorded dates of molting by King Rails are May 28, 1960, and May 29, 1964, when an adult or subadult male and female, respectively, were found in breeding condition at Woodland Beach, Del. The male had pinfeathers on the underside of the neck, the sternal region, and the crural tract. Feather renewal on the female appeared to be about three-fourths complete and was proceeding simultaneously in most areas of the body. Three King Rails in breeding condition examined at Laurel, Md., June 12 and 18 and July 3, 1965, also were molting body feathers.

Molting rails in breeding condition have previously been reported. Watson (1962, p. 350) collected molting Spotted Rails (*Pardirallus maculatus*) in breeding condition in Cuba; Warner and Dickerman (1959, p. 50), working near Mexico City, reported two female King Rails (*Rallus elegans tenuirostris*) molting in May during the nesting season.

My earliest example of a King Rail molting its wing and tail feathers was at Laurel, Md., July 7, 1965. This bird was flightless. Two other birds trapped at Laurel, one on July 14, 1967, the other on July 24, 1967, also were flightless. A female collected near Woodland Beach, Del., July 30, 1964, had nearly completed molting. Its new remiges and rectrices were about half grown, and there was evidence of a late stage of feather replacement in all tracts except the head and upper neck regions.

A captive subadult female began molting wing and tail feathers by the latter half of July. Two of three adults collected in Delaware on August 23, 1963, had nearly completed their molts of wing and tail feathers; the third had no wing or tail feathers.

On August 3, 1967, I took two birds from the Nanticoke River marsh, Vienna, Md., that had not yet begun to molt.

The molting period for the Clapper Rail in the Middle Atlantic States is apparently the same as that for the King Rail. A pair of molting Clapper Rails in breeding condition was collected at Woodland Beach, June 29, 1964. Only the body feathers were being molted.

Robert E. Stewart (1952, p. 57) trapped and banded many Clapper Rails at Chincoteague, Va., and made the following notes on their molt:

> During the trapping period [July 16–August 31] most of the adults were undergoing their post-nuptial molt . . . The individual molting period lasts about one month. The first adult observed in full molt was trapped on July 21. During the period August 24 to August 31 (period just before hunting season) a total of 11 adults were trapped. Of these only 5 had completed their molt and were capable of flight, while 4 were in heavy molt, and were completely flightless. Surprisingly enough the other two adults had not even started to molt and were in very worn plumage.

In a group of young captive King Rails, the postjuvenal molt was underway when they were 50 days old. Molting of the body feathers began before the young could fly, when the flight feathers were about one-half to three-fourths unsheathed. Another group of young King Rails, raised in captivity after being hatched on June 7, completed their postjuvenal molt by the end of the first week of September.

Breeding Biology

Studies of the breeding biology of the King Rail were made mostly on the Grand Prairie in Arkansas and Prairie Counties, Ark., during the period 1951–55.

In late winter when rails return to the prairie from more southern latitudes or simply become conspicuous in areas where they have been present all winter, the most suitable habitat for the establishment of nesting territories is the narrow strip of marsh found in roadside ditches. At this season there is little suitable cover elsewhere. Old rice stubbles are sometimes used for nesting, but many of these are dried up or whipped down by winter winds and rains or are plowed under in the early spring.

HOMING

Some males or females return to the same territory in consecutive years. An incubating bird of undetermined sex banded on a nest at Stuttgart, Ark., May 6, 1952, was recaptured the following year on May 1, on a nest 30 feet from the previous year's nest site. An incubating bird of undetermined sex was banded on its nest at the Patuxent Wildlife Research Center, Laurel, Md., July 3, 1965, and recaptured in a trap with a mate and brood of eight young on July 8, 1966, 50 feet from the 1965 banding site.

TERRITORIES

Territories occupied by King Rails in roadside ditches consist of small strips of fresh-water marsh. The dominant plants in most of these small marsh strips (in order of relative abundance and consequently of relative importance as nesting cover for King Rails in 1952) were soft-rush, awl-fruited sedge, bottlebrush sedge (*Carex comosa*), lake sedge, common spikerush, beakrush (*Rhynchospora* sp.), an undetermined Graminae, broad-leaved cattail, and smartweed (*Polygonum* sp.).

The schedule of arrival of males in the area and the stage of courtship determine size and choice of territory. It is conceivable that the earlier arrivals manage to claim larger and more suitable territories than those which arrive later when competition is keener. However, territorial boundaries are rather fluid during the earlier part of the courtship period. As additional males move into an area of suitable roadside ditch habitat, the large courtship-feeding territories of the first contingent tend to shrink.

Initial occupation of territories is indicated by the mating call. During the last week in February and the first week in March 1955, one male King Rail gave the mating call at various points along 975 linear feet of roadside ditch. By the second week in March its mating call was heard from about 500 feet of roadside ditch; its territory then was about half its original size. The diminishing of the territory was caused by: (*a*) Pressure from another courting male, (*b*) burning of cover along part of the ditch bank within the original calling territory, and (*c*) relatively modest territorial requirements for nesting, particularly if there is plenty of water and ample aquatic animal life for food in the area about the nest.

Approximate sizes of nesting territories were determined by measuring the distances between three active nests in the same ditch; from the center nest it was 298 feet to the nest on one side and 166 feet to the nest on the other side. The ditch was about 30 feet wide at all three points.

Defense of territories

King Rails defend their territories both inter- and intra-specifically. When another King Rail invades a territory, the possessor often prepares to charge by coming to a "freeze," assuming a partial crouch, drawing in its neck, and slowly ruffling its feathers. It then chases the intruder on foot and on the wing.

As additional King Rails move into suitable nesting habitat, there is much fighting, particularly near boundaries of the more desirable territories. I observed a typical skirmish in a narrow ditch bordering a secondary road on April 21, 1955. At this unstable territorial boundary, two males attacked each other with bill and claws, sparring like fighting cocks for about 20 seconds. Then the battle suddenly ended, and the birds moved in opposite directions.

On April 22, 1955, in a rice stubble which appeared to be a common feeding ground for the occupants of the adjacent section of roadside ditch, two males (each already paired) "squared off" in a bitter encounter lasting 3 minutes. There was much chasing both on foot and on the wing and clashing "fighting cock style." W. E. D. Scott (Bent, 1926, p. 287–288) reported similar fighting by Clapper Rails (*Rallus longirostris scotti*) during the courtship period:

> "During the mating season the male birds are very pugnacious and resent any intrusions from others of the species. At such time I have seen them have pitched battles, and finally, one giving in and taking to flight, the victor would pursue the vanquished on the wing for several hundred feet . . .

Sora Rails, migrating through the Arkansas rice country in spring, frequent roadside ditches occupied by King Rails on established nesting territories. One King Rail made four passes in running flight at a Sora in order to evict it from his territory. Virginia Rails received the same treatment from King Rails.

A call, presumably agonistic, heard when two male King Rails were in the same territory, could be described as *kik-kik-kur-r-r-r-*.

COURTSHIP BEHAVIOR

Mating call and pair formation

With the first warm days of late February, the mating calls of King Rails are heard for the first time in the roadside ditches adjacent to rice stubbles or other fields. Rails feed in the shallow water of the ditch and use the broomsedge (*Andropogon* spp.) on ditchbanks or outside levees of old ricefields as places of retreat or hiding. Moreover, the rails use little lanes or pathways, such as those made by cottontails (*Sylvilagus* sp.), for traveling in concealment along the ditchbanks. In late February the only vegetation that offers much concealment to calling King Rails is the perennial ditchbank sedge which is also the winter abode of the Short-billed Marsh Wren on the Grand Prairie; consequently, much of the early season calling emanates from behind or among clumps of this grass. However, where there happens to be an old growth of cattails in the ditch, rails may call from this cover.

The male King Rail calls its mate from a concealed, partly concealed, or completely exposed position. The purpose of this call is first to attract a mate and later, after pair formation, to rally her.

The mating call is one of the least difficult calls to describe. It is most commonly given as a harsh *kik-kik-kik-kik-kik-*, but occasionally varies from a series of *kiks* to a series of *kuks* or *bups*. This variation may be a matter of interpretation, possibly depending upon the observer's distance from a calling bird. The pitch of the call is steady, but the tempo increases from time to time. One bird was heard and seen to give this call continuously for 18 minutes. In the Arkansas ricefields this call was heard at almost any time during daylight, but less frequently at night. At Elliott Island, Md., in the Chesapeake Bay country, I often heard the mating call after 10 p.m. D. J. Nicholson (personal communication) heard dozens of these rails calling all through the night on the Kissimmee Prairie, Fla., in January and February 1962.

I have never heard a female give the mating call.

Other calls

The most characteristic call of the King Rail, the primary advertising call, is the one that is heard throughout the breeding season. It may be written as *jupe-jupe-jupe-jupe-jupe-* or *cheup-cheup-cheup-cheup-cheup-* or sometimes as *gelp-gelp-gelp-gelp-gelp-*. The first several notes in a series are louder than succeeding ones, and the tempo increases rapidly toward the end of the call when the notes run together. One rail gave 25 distinct *jupes* in a single series, not including those in the rapid ending which could not be counted. This call carries a greater distance than the mating call and is somethimes answered by a number of other King Rails. It is sometimes used when a bird is startled and occasionally serves as an "all is well" call when a pair of separated birds are reunited. In addition, I have often observed an incubating bird using this call when it wishes to be relieved at the nest. The primary advertising call of the King Rail is slower and more deliberate than that of the Clapper, which is usually more of a rapid *chac-chac-chac-chac-chac-*.

A call uttered during prenuptial courtship by both the male and the female, but more frequently after pairing, is a soft and rapid *tuk-tuk-tuk-tuk-tuk-*. This sound reminds me somewhat of the clapping together of the mandibles of the Barred Owl (*Strix varia*), and is seldom audible to the human ear beyond 20 or 30 feet. The King Rail uses the "tuk" call as a rallying call or gives it to indicate its position to its mate.

Display

The display of the male during prenuptial courtship is relatively simple and consists mostly in walking about with tail uplifted and white undertail coverts extended (fig. 21–1). In this position the white undertail coverts can be seen from a considerable distance. While flashing its white undertail coverts, the rail usually flicks its tail up and down slightly. Females that I observed during the period of prenuptial courtship made no attempt to display.

There were other forms of posturing during the period of courtship and mating, but apparently the cocked tail and well-exposed white undertail coverts, accompanied by the mating call, are the principal means of attracting a mate.

On two occasions I observed what appeared to be another form of display, the "pursuit display." The circumstances and the behavior of the male were essentially the same both times. In each case the male apparently had not succeeded in attracting a mate to his territory. On March 1, 1955, at 8:30 a.m., I saw a small and very rufescent King Rail, later established to be a female, moving along a rice levee bordering a roadside ditch and approaching a calling male. The female continued along the water's edge at a slow but steady gait and passed beyond the male that was standing in the ditch. As soon as she was ahead of him, the male followed her at a fast walk with head and neck outstretched, bill open (but emitting no sound audible at 40 feet), tail cocked, and white undertail coverts extended (fig. 21–2).

Following pair formation much of the posturing and calling that characterized the period of prenuptial courtship continues, at least

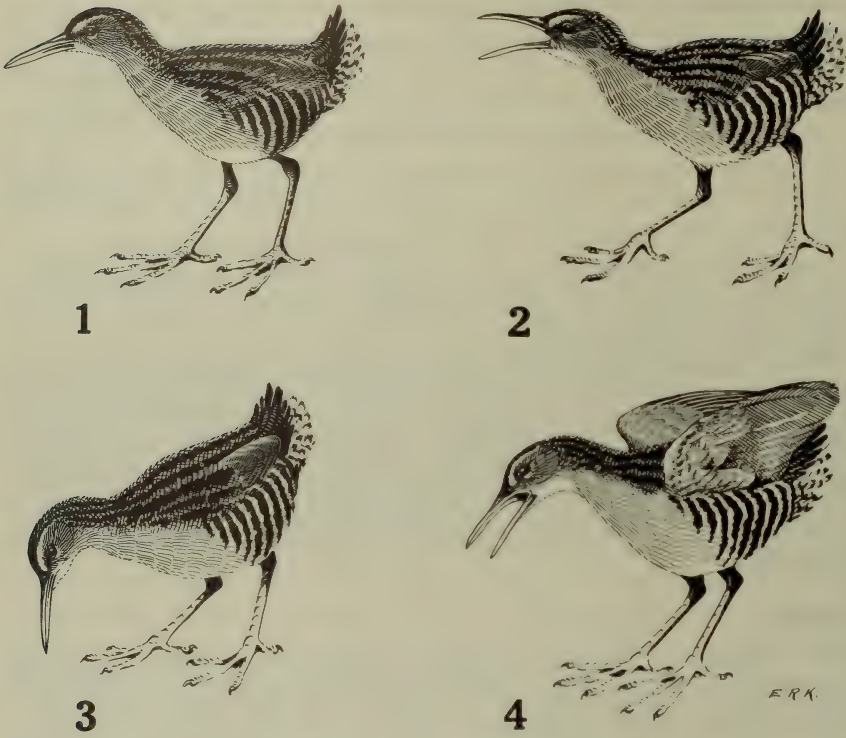

FIGURE 21.—Displays of the King Rail: (1) In the Advertising Display the tail is cocked and the white undertail coverts extended. (2) The Pursuit Display is given when the male pursues the female during prenuptial courtship; the male walks fast or runs with tail slightly cocked, white undertail coverts extended, and bill wide open. (3) The Invitational Display is assumed by the mated male when the female approaches; the bill points downward and slowly swings from side to side, and the tail is displayed. (4) A variation of the Invitational Display consists in wings arched, head turned to one side, bill open, and tail displayed.

in the earlier phases of nuptial courtship. While pair formation is in progress, but infrequently during the nuptial courtship period, the female utters a *purr* or *churr* sound, like the *purr* of a cat, especially after the male has given the mating call.

The male uses the mating call (*kik-kik-*) infrequently and with less vigor when rallying a newly won mate which often strays when foraging. I observed a good example of the use of this call shortly after pairing on the evening of March 2, 1955. During an 18-minute period beginning at 5:30 p.m., a paired male, while standing partially concealed on a ricefield border levee, uttered the complete mating call seven times. Six of the seven times his mate ran to him from a distance of 100 feet or less where she had been feeding. When the female came up beside him, the male spread his white undertail coverts and bent his head and neck so that his bill was perpendicular to and nearly touching the ground (fig. 21–3). From this position, he often turned his bent head with bill open toward the female. At one of these meetings the male appeared to be about to mount the female and begin to rise up with his bill still wide open, but the female evidently was not ready for copulation and walked away.

I observed the same posture many other times, but the birds were usually standing in water. On these occasions the bill usually touched or slightly dipped into the water. Males assumed the pose after pairing, when the feeding female that had been at some distance away came within 3 or 4 feet of her mate. On one occasion a male under such circumstances arched his partly opened wings (fig. 21–4).

Courtship feeding

Courtship feeding, a type of symbolic display that aids in maintaining the pair bond, was observed during the courtship, egg laying, and incubation periods of the King Rail. In the Arkansas ricefields, the crayfish was the only food that I ever saw presented to a female. In Delaware Bay marshes, the fiddler crab was used for this purpose. The male usually brings the food item to the female, but sometimes he may stand where he catches the crustacean, holding it in his bill, until the female approaches and takes possession.

A mated pair of rails that I observed for a number of days on their Delaware breeding territory would descend at low tide from the marsh to a pool in the bed of a tidal creek. The female would usually stand in the pool while the male hunted food for her. He would frequently run up the winding creek bed for 25 yards or so, catch a fiddler crab, and run back to present it to the female. Why he often traveled such distances when there were plenty of fiddlers nearby is not known.

During a 2-hour period of observation in an Arkansas ricefield, I saw the male of a pair catch seven crayfish, five of which he presented to his mate.

PRENESTING ACTIVITY

Calling

As the nesting season approached, the mating call and undertail covert flashing by the male all but ceased, and the addition of a number of calls, mostly soft or subdued, increased the repertoire of the mated pair. Paired rails used such calls as rallying devices when separated or as reassuring answers to one another's calls when together.

A call frequently given by both birds, particularly as nesting approached, was a very soft *poyeek-poyeek-poyeek-poyeek-poyeek-*, or *wyeek-wyeek-wyeek-wyeek-wyeek-*, which seemed to act as an inquiry of the whereabouts of the mate.

Several males gave one of the more unusual calls, a deep booming sound requiring an effort which caused the body to appear to expand slightly and sounding something like *óom-óom-óom-óom-óom-*. The purpose of his "booming" call is not known. It is not very loud, and the females were not nearby when it was uttered, unless they were well concealed.

Symbolic nest building

Symbolic nest building was observed at Stuttgart, Ark. In this case a male King Rail was observed carrying nesting material into a hole in a ricefield dike through which water was draining into a roadside ditch. The dike was about 2½ feet in height, and the hole was large enough for the bird to pass easily from one side to the other. The light stream of water did not prevent an accumulation of nesting material. However, the nest was not completed. Two days later (April 2) the true nest was started about 10 yards from the hole in the dike.

Copulation

Copulation usually takes place near the nest site, before and during egg laying. Although no nests with eggs were found on the Arkansas Grand Prairie before March 25, rails were observed copulating as early as March 3, in 2 different years. Perhaps these birds nested earlier than March 25.

On one nesting territory, the male came within 20 feet of the nest (containing one egg), called, and was answered by the female who left the nest and came to the male for copulation. The *jupe-jupe-jupe-jupe-jupe-* call often precedes copulation during this period. Copulation is performed with the female assuming a crouch and the male mounting with legs and feet placed on the female's back.

NESTING PERIOD

The nesting period varies with latitude, being longer and starting earlier in the southern part of the range. The nesting period in Florida extends from late January, at least, until the middle of July, and in Louisiana from early March to September. It is quite conceivable, therefore, that in such States as Florida and Louisiana the breeding season covers 7 to 8 months. Unlike the Bobwhite (*Colinus virginianus*), Redwinged Blackbird, and several other species which do not nest much earlier in the gulf coast region than in the northern States, the King Rail takes advantage of the long warm period, and nests over a longer period of time. The long period of nesting in the South should result in a greater total production of young, because of the much greater opportunity for renesting and second broods. The nesting season in the Middle Atlantic States is about 4 months; adults with downy young have been observed in early August in Delaware.

With the long warm period prevailing in the Deep South, time for raising more than one successful brood would seem to be ample. A breeding pair is busy with nesting activity for about 2 months (approximately 10 days for laying, 21–22 days for incubation, and 24–30 days with brood). As yet there is no evidence that the King Rail is double-brooded; however, no attempt has been made to determine this. The closely related Clapper Rail in South Carolina is double-brooded (Blandin, 1963, p. 66–67), and it is probable that some King Rails in the Deep South also have more than one successful brood during a season.

A nest found in a cypress pond in southern St. Johns County, Fla., in February 1933 contained 11 eggs in an advanced stage of incubation (Hallman, 1934, p. 18). Allowing a 21- or 22-day incubation period plus 11 days for laying, it is conceivable that this nest was started in January. D. J. Nicholson found a dead King Rail at Orlando, Fla., on February 16, 1925, with a hard-shelled egg ready for deposit (Howell, 1932, p. 203). A single downy young King Rail was seen on March 10, 1950, 2 miles west of 40-mile Bend, Dade County, Fla., by J. C. Moore and D. B. Beard (U.S. National Park Service files). W. B. Robertson, Jr. (personal communication), found several young King Rails at Royal Palm Hammock, in the Florida Everglades, on March 5, 1952. These last two examples indicate February nesting.

Adults with six young approximately 2 weeks old were recorded in Lee County, Fla., July 30, 1966, indicating that the nesting season in Florida extends into July (Frederick H. Lesser, personal communication).

At Oakland Plantation, a few miles north of Charleston, S.C., a brood of 10 young were seen by Francis Porcher on March 22, 1913 (Sprunt and Chamberlain 1949, p. 193). In this case nesting started in early or mid-February. I found young 1 to 4 days old (egg tooth present) and a nest of nine eggs in Jasper County, S.C., near Savannah, Ga., on April 16, 1961, and young at Georgetown, S.C., on April 25, 1961.

At Grand Chenier, Cameron Parish, on the southwestern coast of Louisiana on April 8, 1956, I observed a pair of King Rails feeding 2-week-old young. Back-dating about 38 days to cover the age of the young and the incubation period, laying began about March 3.

Fifty miles north in the Louisiana rice country, nesting probably gets underway a little later than on the coast. A nest of seven eggs was found at Mamou, March 30, 1957. A late nest containing eight eggs was found at Mamou, August 6, 1955.

On the Arkansas Grand Prairie, the important nesting months are April, May, and June (table 8). The earliest indication of nest building is in late March (March 25). During March 1952, nearly all King Rails seen were in pairs.

In Maryland, most clutches are laid between May 15 and June 30. A brood of chicks and their parents were seen by P. J. Van Huizen near the Blackwater River, Dorchester County, on May 21, 1965, giving evidence that some King Rails begin nesting in April.

In Central Ohio, Milton B. Trautman and R. Bales located 42 nests, 34 of which were found in May and 8 in June (M. B. Trautman, personal communication). Seven of the June nests were found during the first half of the month, and 26 of the May nests were found during the last half of that month. From this, the main nesting period seems to extend from May 15 to May 31.

TABLE 8.—*Nesting dates, clutch size, and habitat of King Rail nests at Stuttgart, Ark.*

Nest number	Date found	Number of eggs [1]	Complete clutch size [2]	Number hatched	Location	Dominant vegetation
1	Apr. 1, 1952	1	11	8	Ditch	*Typha latifolia.*
2	Apr. 10, 1952	*b*	2*d*		Canal	*Juncus* sp.
3	Apr. 15, 1952	4	12	12	Ditch	*Typha latifolia.*
4	Apr. 16, 1952	11	11	9	do	Grass?
5	Apr. 21, 1952	10	10	9	do	*Juncus effusus.*
6	do	14	14	14	do	*Carex hyalinolepis.*
7	Apr. 24, 1952	4	4*d*		do	*Carex hyalinolepis.*
8	Apr. 25, 1955	6			do	*Eleocharis* sp.
9	Apr. 26, 1955	13			do	Sedge.
10	do	2			do	*Juncus effusus.*
11	do	*new*			do	*Juncus effusus.*
12	May 1, 1952	1	1*d*		do	Sedge?
13	do	11	11	11	do	*Typha latifolia.*
14	May 2, 1952	*new*	*d*		do	*Juncus effusus.*
15	do	11	11	10	do	Sedge?
16	May 5, 1962	10		8	do	*Carex stipata.*
17	May 6, 1952	5	11	9	do	*Juncus effusus.*
18	May 9, 1950	4	5*d*		Ricefield	*Oryza sativa.*
19	do	6	11		Ditch	*Juncus effusus.*
20	May 10, 1948	12	12		Oat field	*Avena* (var.).
21	May 10, 1952	9	9	9	Ditch	*Juncus effusus.*
22	do	11	11	10	Canal bank	*Bromus secalinus.*
23	May 11, 1952	12	12	10	Ditch	*Juncus effusus.*
24	May 12, 1962	12		(?)	do	*Carex stipata.*
25	May 13, 1952	10	10	0	do	*Juncus effusus.*
26	May 13, 1962	11		(?)	do	*Eleocharis palustris.*
27	May 15, 1962	10		(?)	do	*Carex stipata.*
28	May 26, 1952	2	2*d*		Canal bank	Grass?
29	May 26, 1954	10		10	Ditch	*Eleocharis* sp.
30	May 28, 1952	4	8	8	do	*Juncus effusus.*
31	June 3, 1954	3		(?)	do	Grass? and sedge?
32	June 4, 1952	*eb*			Weedy field	*Avena (var.).*
33	June 9, 1952	10	10	10	Canal bank	*Oryza sativa.*
34	June 13, 1952	7			Ricefield	*Paspalum distichum.*
35	do	*eb*			Pond edge	*Paspalum distichum.*
36	do	*eb*			do	*Oryza sativa.*
37	June 19, 1952	9	0		Ricefield	*Oryza sativa.*
38	June 25, 1952	10	10		do	*Oryza sativa.*
39	July 15, 1950	(3)			do	*Oryza sativa.*
40	do	(3)			do	*Oryza sativa.*
41	do	(3)			do	*Oryza sativa.*
42	do	(3)			do	*Oryza sativa.*
43	do	(3)			do	*Oryza sativa.*
44	July 18, 1951	7	9		do	*Oryza sativa.*
45	Aug. 1, 1950	6	8*d*		do	*Oryza sativa.*
46	Aug. 9, 1951	5	5*d*		do	*Oryza sativa.*
47	Aug. 9, 1963	5	5	0	do	*Oryza sativa.*
48	Aug. 10, 1951	6	6*d*		do	*Oryza sativa.*
49	Aug. 29, 1951	9	9		Ditch	*Echinochloa* sp.

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[1] *b* = building; *eb* = eggs broken.
[2] *d* = deserted.
[3] Nest and eggs found; clutch size not recorded.

Tanner and Hendrickson (1956, p. 54) reported that in Clay County, Iowa, nesting begins soon after the arrival of the birds during the first week of May.

> In 1951 the nesting season extended for a period of 42 days from May 13, the date that the first egg was laid, until June 23, the date that the last egg hatched.

NEST SITE AND MATERIALS

The usual nest site is in the shallow-water part of a marsh. The water depth was 4 to 18 inches at Clay County, Iowa (Tanner and Hendrickson 1956, p. 55), 2 feet at Buckeye Lake, Ohio (Trautman 1940, p. 229), and 6 to 8 inches in Arkansas ricefields. In South Carolina, Wayne (1910, p. 35) found nests in buttonbushes 8 to 18 inches over water.

In a giant cutgrass marsh near Savannah, Ga., each of five nests located was within 20 feet of the edge of the marsh, although the vegetation density and other characteristics appeared uniform over extensive areas.

Occasionally a nest is placed on a dry-land site such as an oat or wheatfield, or on a grassy embankment. In 1952, on Long Island, N.Y., Roy Latham (1954, p. 3–9) found a nest on the ground in a potato field, 150 yards from the edge of a salt marsh where Clapper Rails were nesting.

The nest site appears to be chosen by the male. On two occasions, I have seen a male initiate nest-building.

Most King Rail nests are placed in fairly uniform stands of vegetation and are well concealed, but the shape of the nest canopy (whether cone-shaped or round) sometimes disrupts the uniform pattern of the vegetation and reveals the location of the nest to the human eye (figs. 22 and 23).

The life form of some plant in the territory, such as a tussock of grass or the stool of a rice plant, often determines the exact nest site. A nest may be placed in a clump of grass or a sedge tussock, or between several clumps, parts of which are used in fashioning the canopy and sides of the nest. The bases of most Arkansas nests were made of wet decaying plants, and the platforms or cups were of dead dry grasses, sedges, or rushes. These materials are obtained near the nest site. The base of one nest found in Arkansas was made entirely of mud and was 2¼ inches in depth.

Nest materials used in some Iowa nests consisted of one or two species of plants (Tanner and Hendrickson 1956, p. 55). Most nests in Arkansas ricefields were made of rice plants; a few were made from "weed" plants in the fields, such as wild millet. The completed nest is a round, elevated platform with a saucer-shaped depression (figs. 23, 24, and 25). It usually has a round or cone-shaped canopy and a ramp, and is nearly twice as large as that of the Virginia Rail or Sora.

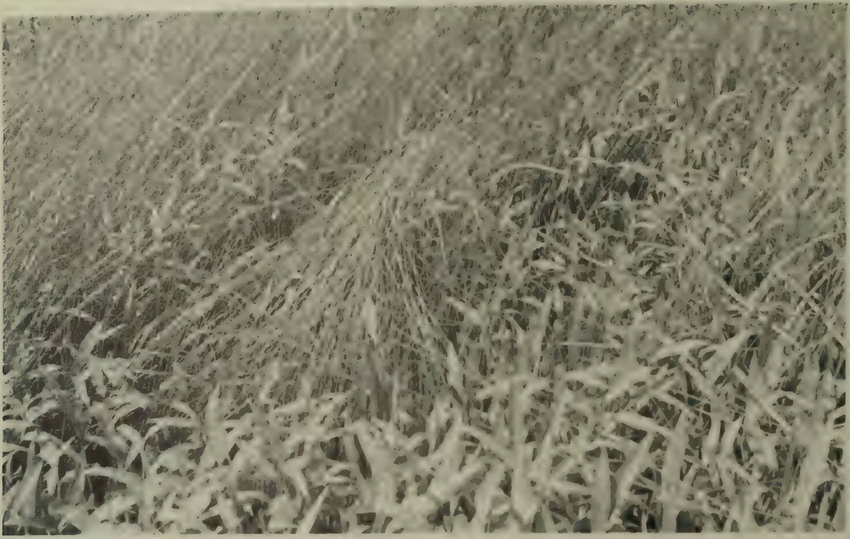

FIGURE 22.—Canopy of King Rail nest in roadside ditch, Arkansas Grand Prairie. In a uniform stand of vegetation the canopy is often quite conspicuous. Canopy composed of spikerush (*Eleocharis palustris*) and smartweed (*Polygonum* sp.).

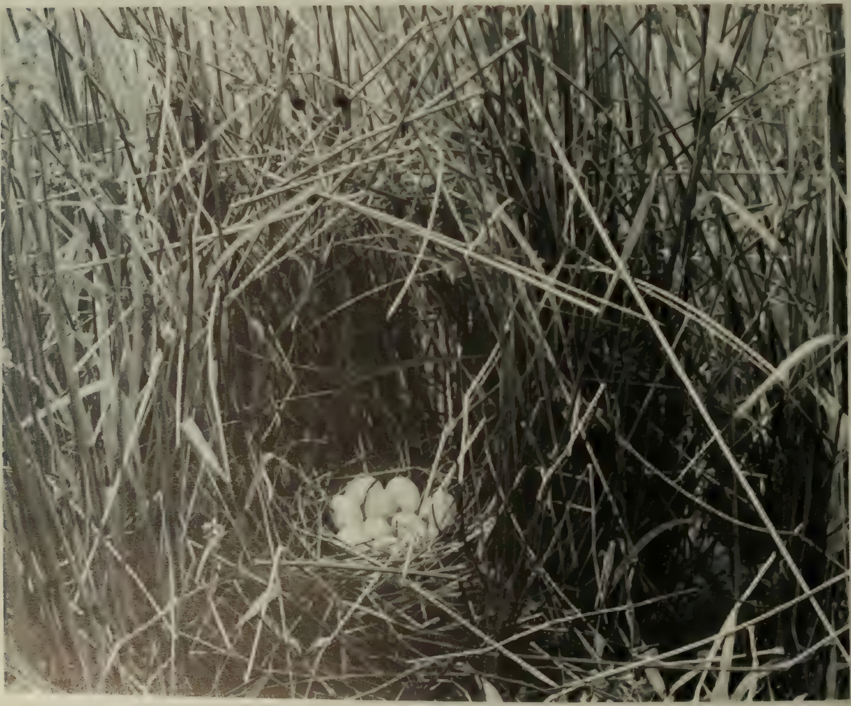

FIGURE 23.—King Rail nest in roadside ditch near Stuttgart, Ark., May 30, 1952. Nest constructed of softrush (*Juncus effusus*).

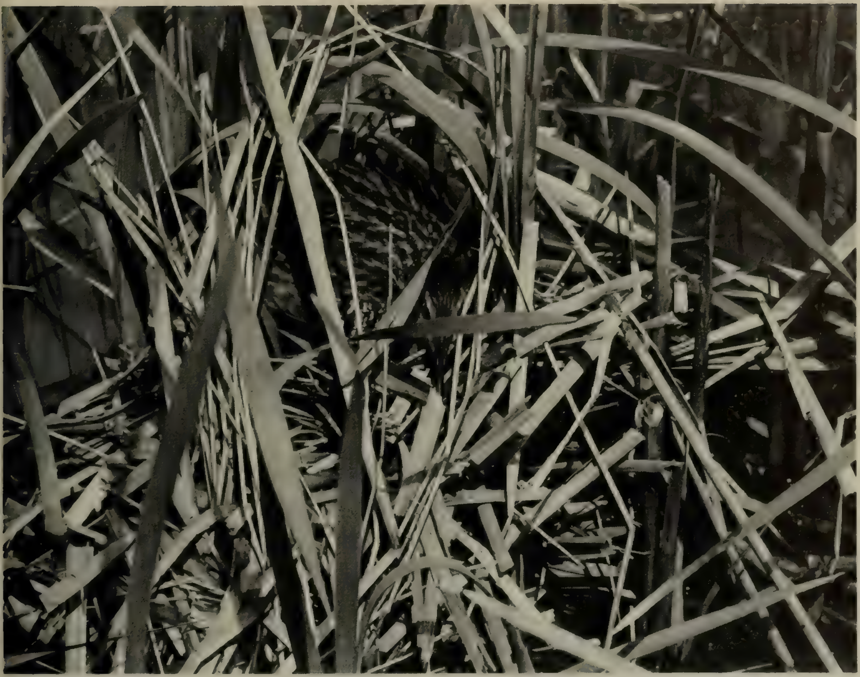

FIGURE 24.—King Rail incubating in nest constructed of cattails (*Typha latifolia*) in roadside ditch, Arkansas Grand Prairie, April 1952.

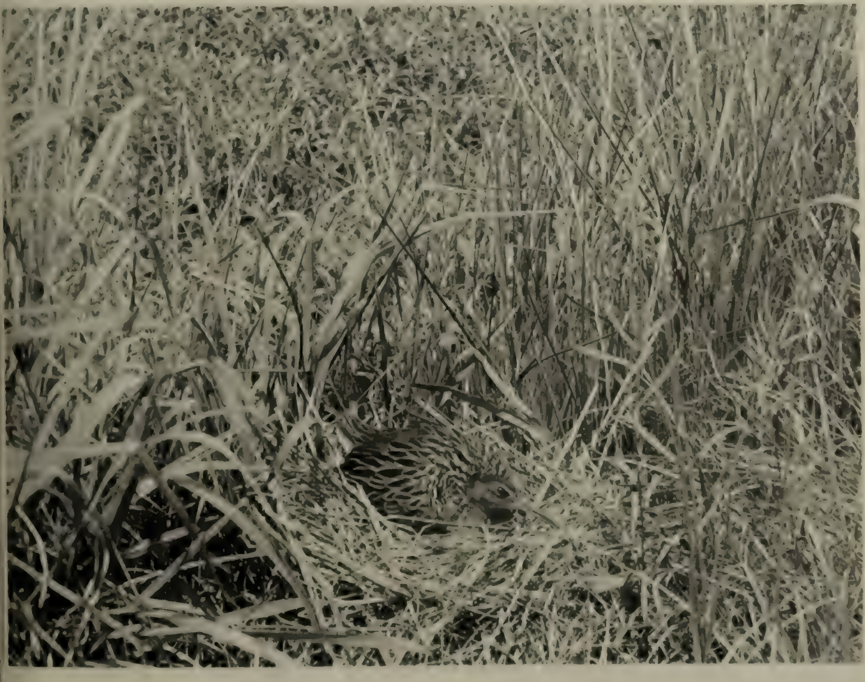

FIGURE 25.—King Rail incubating in open nest along roadside ditch, Mamou, La., April 1957.

Dimensions of 11 eastern Arkansas nests were: average height from ground to canopy, 43.0 cm.; average height from ground to rim, 16.5 cm.; average exterior diameter, 28.0 cm.; and inside depth, 1.5 cm. (Meanley, 1953, p. 265).

The height of the nest above water usually depends upon the depth of the water. Eggs in most nests in Arkansas Grand Prairie ricefields were less than a foot above the water level. In tidal marshes along the lower Savannah River, S.C., the eggs in two nests were about 2 feet above the low tide mark and about 1 foot above the high water mark. Nests in dry locations, such as oatfields, canal banks, or dry ditches, are usually elevated very little, and the eggs may rest within an inch or two of, or actually on, the ground. Nests placed above 2 or 3 inches of water may be elevated as much as a foot during a heavy rain or when a dry ricefield is being flooded.

After a heavy rain on the Arkansas Grand Prairie, an incubating rail was observed working rapidly to build up its cattail nest above the rising water in a roadside ditch. By reaching out with its bill all around the nest and picking up materials (mostly cattail leaf fragments), which it tucked beneath the eggs, and by using most of the canopy for the same purpose, the bird managed to keep the eggs about 2 inches above the rising water. The ditch was nearly dry before the rain, and the eggs were then 5 inches from the ground. At peak depth, the water was 21 inches deep. On another occasion, a nest with eggs 2½ inches from the ground was located in a ricefield that had been temporarily drained. The next day, the field was flooded to a depth of 5 inches, and the eggs were raised to 7 inches from the ground. As the water continued to rise, the incubating bird persisted in elevating the eggs by tucking rice leaves from the canopy under them.

On one occasion I came upon a bird constructing a nest on a canal bank, and watched the process only a minute or so before its mate came to continue the work. The bird that was relieved left to feed in a nearby ditch. I watched the newcomer for about 3 minutes, and then collected it. Upon dissection it proved to be the male.

Apparently the male takes the more active part in nest building. Males on three occasions were observed gathering nest material within 20 feet of the nest site. A captive male purred like a domestic cat constantly as it carried nesting material to the nest site. The nest is shaped as the bird (all observations were of males) sits in a clump of grass or between clumps and semirotates its body. It later piles up dead vegetation, and shapes the cup. The canopy is formed by bending over the tops of stalks of adjacent plants. One Arkansas nest was observed under construction at 8 a.m. and 6:30 p.m. of the same day, another one at 12:15 p.m. and 5:15 p.m.

The nest is not always completed before the first egg is laid. While driving along a paved road 5 miles south of Stuttgart, Ark., at 5:30

p.m. one day in May, I heard two rails uttering their characteristic *jupe-jupe-jupe-jupe-jupe* call. One of the birds was standing in a nearby ditch, and after about 3 minutes of watching, I saw the grass move on the bank near the rail in view. As the same grass continued to move, it was evident to me that the mate was building a nest. Actually the bird was pulling in grass to form the sides and canopy for a nest. After watching it for a few minutes I departed. The next morning I found that construction was in the initial stage, but two eggs had been laid on the bare ground and were surrounded by just a few dead plant fragments.

A Purple Gallinule, another species of Rallidae, was reported by Grimes (1944, p. 63) to have a nest platform 6 inches thick when the first egg was laid. As the eggs began to hatch, the nest was built up until it was 13 inches thick.

Similar nest building activity by Clapper Rails at Frogmore, S.C., was reported by Hoxie (1887, p. 181):

> The first time I found the nest it contained only one egg, and did not seem wide enough to hold more than one more. . . . As each new egg was laid they added fresh material to the outside, until the nest was at least amply sufficient to contain the full set of eight.

Several brood nests, usually without canopies, are constructed near the egg nest.

EGG LAYING AND CLUTCH SIZE

Eggs were deposited daily at five Arkansas nests. In one Arkansas nest, the eggs were laid between 7 p.m. and 7 a.m. In one South Carolina nest, Wayne (1910, p. 36) noted that each egg was deposited after 11 a.m.

Parasitism or "dumping" was recorded by B. H. Swales (1896, p. 142) in St. Clair County, Mich. On June 9, a King Rail was flushed from a nest containing 17 eggs; nine were apparently laid by the King Rail, seven by a Virginia Rail, and one by a Sora.

Clutch size

Clutches of 10, 11, or 12 King Rail eggs are most frequently found (table 9). A smaller clutch may represent a replacement clutch, depending upon when it occurs. On the Arkansas Grand Prairie, the earliest clutch of eight eggs was found on May 28, approximately 2 months after the beginning of the laying season. In Maryland, in July, I observed three complete clutches of six eggs each.

Description of eggs

Bent (1926, p. 261) gives the following description of the eggs:

> They are ovate in shape and the shell is smooth and slightly glossy. The ground color averages lighter than in eggs of the clapper rails, but not so light as in

those of the California species; it is pale buff, varying from "cream buff" to "pale olive buff." They are sparingly and irregularly spotted, mostly in small spots, with various shades of "vinaceous drab," "army brown" and "vinaceous brown" and sometimes with a few spots of brighter browns. The measurements of 56 eggs averaged 41 by 30 millimeters, the eggs showing the four extremes measure 44 by 32, 38.5 by 28 millimeters.

I measured 20 eggs at Stuttgart, Ark. two from each of 10 nests. The average measurement was 40.8 by 30.4 millimeters, with extremes of 42.0 by 32.0 and 39.5 by 29.5.

Table 9.—*Clutch sizes in King Rail nests at three locations*

Clutches with—	Number of clutches found		
	Stuttgart, Ark.[1]	Northern and central Ohio[2]	Delaware Valley[3]
8 eggs		3	1
9 eggs	1	1	3
10 eggs	3	9	3
11 eggs	7	11	2
12 eggs	3	9	4
13 eggs	1	3	
14 eggs	1	1	1
Total	16	37	14
Mean number of eggs	11.2	10.9	10.6

[1] Meanley, unpublished.
[2] Trautman, 1940, p. 229; R. Bales, ms.
[3] Stone, 1937, p. 332; R. F. Miller, correspondence.

Weight of eggs

At Stuttgart, Ark., three eggs weighing 18.9, 20.3, and 18.8 grams were marked on the day they were laid and were weighed on every seventh day until hatching (table 10). The average weight loss was 0.47 gram during the first week, 0.83 gram during the second week, and 1.0 gram during the third week. The average total loss from laying to hatching was 2.30 grams.

INCUBATION

The incubation period is about 21 or 22 days. Roberts (1936, p. 440) stated that A. M. Bailey found the incubation period to be about 21 days. In Clay County, Iowa, Tanner and Hendrickson (1956, p. 55) found it to be approximately 21 days. Incubation periods of four Arkansas clutches were 21 days, 22 days, 22 or 23 days, and approximately 23 days.

One Arkansas nest was under daily observation from the time the first egg was laid on April 1 until the last egg hatched on May 4. Eleven eggs were in the completed clutch, and incubation started with the laying of the 10th egg on April 10. At another nest in Arkansas incubation began on April 22 or 23, and the eggs hatched on May 13 and 14. A nest at Mamou, La., contained 9 eggs on June 9 and 10 hatching eggs on June 30.

Both sexes incubate. To prove this, one night between 9 and 10 p.m., I placed white paint in a small can at the end of a long stick and poured it on the backs of incubating birds at two nests. On subsequent visits to the nests, unmarked birds were often seen incubating.

TABLE 10.—*Weight loss in three King Rail eggs during incubation*

[In grams]

	Weight on—			
	Day 1	Day 7	Day 14	Day 21
Egg 1	18.9	18.7	17.8	16.7
Egg 2	20.3	19.5	18.8	17.9
Egg 3	18.8	18.4	17.5	(1)
Mean	19.33	18.86	18.03	17.3

[1] Clutch destroyed.

Later that season an exchange of sexes was observed at a nest during the incubation period. At 5:18 p.m. an incubating bird called from the nest, whereupon its mate immediately came from the cattails across the road to a point about 20 yards from the nest, and began walking toward the nest until it was within 5 feet. The incubating bird then left the nest and was replaced by its mate, which remained on the nest for 17 minutes, when an exchange again took place.

In another instance, when one member of an Arkansas pair nesting near a road was killed by an automobile, its mate continued to incubate the eggs. An incubating bird caught on a nest at 5:45 p.m. May 16, was a male.

Incubating birds seldom flush until an intruder is within 10 feet or less of the nest. As the hatching date approaches, they become more tenacious. On several occasions I was able to band incubating birds, but not without considerable resistance from them. On one occasion when I approached a nest at hatching time, the bird flew from the nest and struck me in the chest. On other occasions birds have struck at my legs or have run to my feet where they remained with wings outstretched. Frequently they feigned injury by spreading the wings, fluttering through the vegetation (fig. 26), and uttering a distress call which might be written as a gutteral *rack-k-k-*, *rack-k-k-*, *rack-k-k-*, sometimes varying to sound like *chur-ur-ur-ur* (the roll on the *ur* is like the German "R"). Other scolding notes given by a rail flushed from its nest are a resonant *gip-gip-gip-* and *kik-kik-kik-*.

In contrast to this type of behavior, the Clapper Rail is usually gone before the intruder gets near the nest. At Chincoteague, Va., I have examined some 200 Clapper Rail nests, and only on some half dozen occasions has an incubating bird remained while approached to within 10 feet. This appears to be a striking behavioral difference between these two closely related species.

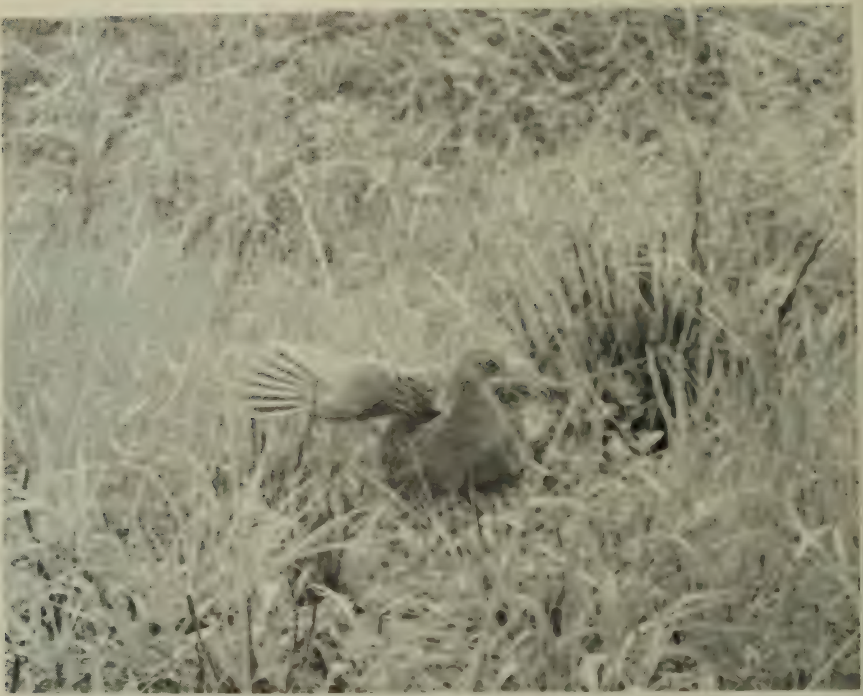

FIGURE 26.—Distraction display of King Rail near nest. This display is characterized by feigning injury and emitting distress call.

HATCHING

Eggs in four Iowa nests hatched within a 24- to 48-hour period, and were pipped from 24 to 48 hours before hatching (Tanner and Hendrickson, 1956, p. 55).

Hatching was observed at Stuttgart, Ark., May 26–29, 1954. When located at 12 noon on the 26th, the nest contained 10 eggs, only one of which showed signs of hatching and had two small pip holes. By 4:30 p.m. the following day (May 27), 9 of the 10 eggs were pipped. At 1 p.m. May 28, 3 eggs had hatched; by 5:30 p.m. that evening, 5 eggs had hatched; and by 10 a.m. May 29, all eggs had hatched. At 4 p.m. May 29, the entire brood and both parents were at the nest; but at 9:30 p.m. the entire family had deserted the nest and was probably spending the night in a nearby brood nest.

At one Arkansas nest the parent birds alternately participated in brooding newly hatched young and hatching eggs. Toward the end of the hatching period the nonbrooding parent was usually observed within 25 feet of the nest, accompanied by several of the chicks.

As eggs hatch the shells are disposed of in several ways. One brooding bird at an Arkansas nest ate most of an egg shell about 5 minutes after the egg had hatched. Shell fragments were found in the stomachs of several adult birds collected during the breeding season. Some shells remain in the nest, disintegrate, and eventually filter down into the base of the nest. Shell fragments are found in virtually all nests that have hatched young.

A pair may remain with their brood for more than a month after hatching. I have collected three-fourths grown young rails that were still traveling with an adult pair in August. In one instance a pair, one of which was marked, and their 3-day-old young still spent most of the day within 20 yards of their nest, and 19 days later were seen only 10 yards from the nest! Once I came upon a brood of young King Rails approximately 3 weeks old traveling with three adult birds.

The call given by an adult with young chicks when all is well is a soft continuous *woof-woof-woof-* (corresponding to the *cluck-cluck-cluck-* of a barnyard hen). An alarmed parent with brood emits a sharp *gip-gip-gip-*, which causes the young to scatter to a hiding place.

NESTING SUCCESS AND SURVIVAL

In Clay County, Iowa, Tanner and Hendrickson (1956, p. 55) found that four of six observed nests hatched one or more eggs each. Of 60 eggs in the six nests, 39 hatched.

Of 16 Arkansas nests I observed, 12 hatched one or more eggs each. The average number of eggs hatched in each of these 12 nests was 9.9. Of a total of 147 eggs in all 16 nests, 119 hatched.

An index of survival based on the number of young over 2 weeks of age is difficult to obtain because complete broods are not always seen. In Arkansas, I observed 10 broods with what I believe were full complements. In each observation, the parent birds were unaware of my presence as the family was crossing a road, feeding in a newly sown ricefield, or moving about in some other comparatively open spot. The number of young per brood ranged from two to nine and averaged five. If my estimate of an average hatching success of 9.9 is correct, then survival rate until 2 weeks of age was about 50 percent.

BREEDING STATUS OF FIRST-YEAR BIRDS

Although I know of no example of juvenile or immature birds being marked and recaptured in breeding condition or in the act of nesting, I collected a nesting bird in what appeared to be first-year plumage in the Delaware Bay marshes. Only the lower throat and upper breast regions of this bird were cinnamon, a whitish area covered most of the lower breast and axillary regions, and the side of its head was considerably paler than average for mature birds. The greater coverts were heavily barred with whitish subterminal bars. The specimen, a female, was extremely small. Measurements were as follows (with adult female average in parentheses): Wing 147.0 mm. (154.3); exposed culmen 54.0 mm. (61.9); tarsus 50.0 mm. (54.0).

Development and Behavior of Captive Rails

DEVELOPMENT OF YOUNG

First-day chick

The newly hatched King Rail is very weak and wet. Contrary to the statements of Audubon (1835, p. 28) and Howell (1932, p. 203), it is unable to run about and follow its parents as soon as it is hatched. Sometimes it emerges from the shell on its back and lies kicking and struggling for some minutes before righting itself. A nest mate may grab its toes or beak and so stimulate further activity. Most of the chicks I have observed were more than an hour old before they were able to go over the side of the nest and return. Chicks 15–20 minutes old had considerable difficulty when we placed them in weeds and water outside their nest, and they could not get back into the nest under their own power.

As the down dries out, the young bird moves more actively about the nest, the undeveloped wings assisting in this effort. As the rail chick begins to gain strength, it sits on its tarsi and assumes a begging display, with wings extended for balance.

The period of fluffing-out often takes half an hour or longer. It took 4½ hours for one of the chicks I observed. The fluffing-out process may be necessary to produce buoyancy needed to enter the water safely, as Gullion (1954, p. 389) suggests for the Coot (*Fulica americana*).

Chicks took food from their parents' beaks the first day, but I did not see them picking up food from the ground until the second day.

The day-old chick has at least two calls: a loud begging call, *chee-up;* and a soft lower-pitched call of contentment, *wee* and *wee-up.*

The day-old chick is covered with black down that has a faint greenish sheen or cast except in areas where it is most dense. The down is very dense on the abdomen and sparse on the crown. The bill has a pied pattern; the basal half of the bill is grayish black, the narial region is white, the distal portion is flesh-colored, and the egg tooth, retained at the tip for 4–6 days after hatching is white. The legs and feet are brownish gray although, at a quick glance, they appear to be black. Eyes are grayish brown. A vestigial claw is present on each wing.

The young bird loses weight throughout the first day of life. One female chick weighed 16.3 grams at hatching, 16.0 grams at 1 hour, 15.7 grams at 2 hours, and 13.2 grams at 24 hours (table 11).

One to thirty days

During the first month of life the major change in the appearance of the King Rail chick is one of size and conformation (fig. 27). A young captive male weighed 16.7 grams when he was 1½ days old, and 96.3 grams when he was a month old. His measurements at 1½ and 30 days, respectively, were: exposed culmen, 11.0 and 28.0 mm.; tarsus, 20.0 and 42.0 mm.; middle toe with claw, 22.0 and 50.0 mm. (table 11.).

The thick natal down is present during most of the first month, but during the fourth week there is evidence of development of the juvenal plumage.

TABLE 11.—*Growth of four King Rails*

Age	Weight (grams)	Length of— Exposed culmen (mm.)	Length of— Middle toe with claw (mm.)	Length of— Tarsus (mm.)
Bird A:				
Hatched	[1] 16. 3			
1 hour	16. 0			
2 hours	15. 7			
1 day	13. 2	11. 0	20. 0	20. 0
8 days	14. 0	12. 5	26. 0	21. 5
21 days	40. 0	19. 5	36. 0	29. 0
60 days	202. 0	40. 0	57. 0	53. 0
90 days	265. 0	49. 0	57. 0	53. 0
Bird B:				
1 day	15. 6			
7 days	18. 9			
17 days	37. 0	20. 0		
21 days	50. 7			
30 days	75. 4	25. 0	42. 5	38. 5
45 days	177. 9	40. 0	49. 0	52. 0
Bird C:				
1½ days	16. 7	11. 0	22. 0	20. 0
7–8 days	25. 7			
17–18 days	46. 5	21. 0	36. 0	32. 0
21 days	63. 8			
30 days	96. 3	28. 0	50. 0	52. 0
45 days	219. 8	40. 0	61. 0	56. 0
60 days	327. 0	48. 0	61. 0	58. 0
Bird D:				
1½ days	15. 6			
7–8 days	19. 7			
17–18 days	32. 0			
21 days	47. 7			
30 days	70. 8	25. 0	43. 0	36. 5
45 days	176. 0			
60 days	258. 6			

[1] Wet.

Toward the end of the first month the young rail begins walking more deliberately and assumes the gait of the adult bird. When it is seeking food, it tips its tail in typical adult fashion. Tail tipping was observed in one 2-week-old chick.

Month-old King Rails have at least four calls: (1) *seep-seep-seep-* (repeated) indicates general satisfaction and, particularly, acknowledges the presence of others and notifies them of its presence; (2) *tah-ee! tah-ee!* (repeated), very high pitched and progressively lower in volume as sleep approaches, indicates relaxed comfort and sleepiness; (3) *soo*, *tsoo* (*tsŏo*) indicates lonely dissatisfaction; (4) *keelp-keelp-keelp-*, a series of five or six hoarse notes in rapid sequence, expresses protest.

Thirty to sixty days

During the second month the juvenal body plumage replaces the natal down. The first juvenal feathers may be obscured by down until the young rail is nearly a month old, but by the seventh or eighth week the development of nearly all of the body feathers is complete. The plumages of four captive King Rail chicks developed at about the same rate through the first 6 weeks, but the rate varied considerably thereafter.

The first evidence of change from the natal down plumage is the appearance of white auricular tufts and pale juvenal feathers on the underparts and flanks (figs. 27 and 28). Feather development in these areas during the fourth week is as follows:

(1) The sternal region of the ventral tract: The pinfeathers are pale buffy brown, and are tipped with natal down that is being pushed out.

(2) The crural tract: Pinfeathers are whitish with black down at the tips.

(3) The femoral tract: Feathers are approximately the same color as those of the ventral tract.

By the latter part of the fifth week the juvenal plumage of most young rails is developing in all body areas, but feathering of the crown and back of the neck may begin slightly later in some individuals. The abdominal region, axillary region, chin, and upper throat are whitish and contrast rather sharply with the dusky upperparts, particularly the lower back and rump. The dark brown feathers of the upper back and humeral tract are well advanced, feathers of the cervical region (lower throat) are approaching a cinnamon color, and the thighs and flanks are faintly barred. The upper and undertail coverts are making their appearance, and the anal circlet is surrounded by short white feathers.

Quills began to appear the latter part of the fifth week on the wings and tails of two of four captive birds. The primary and secondary coverts developed more rapidly than did the primaries and secondaries. The linings of the wings developed last.

By the sixth week the side of the head is whitish and faintly washed with gray. A white supercilliary stripe is beginning to ap-

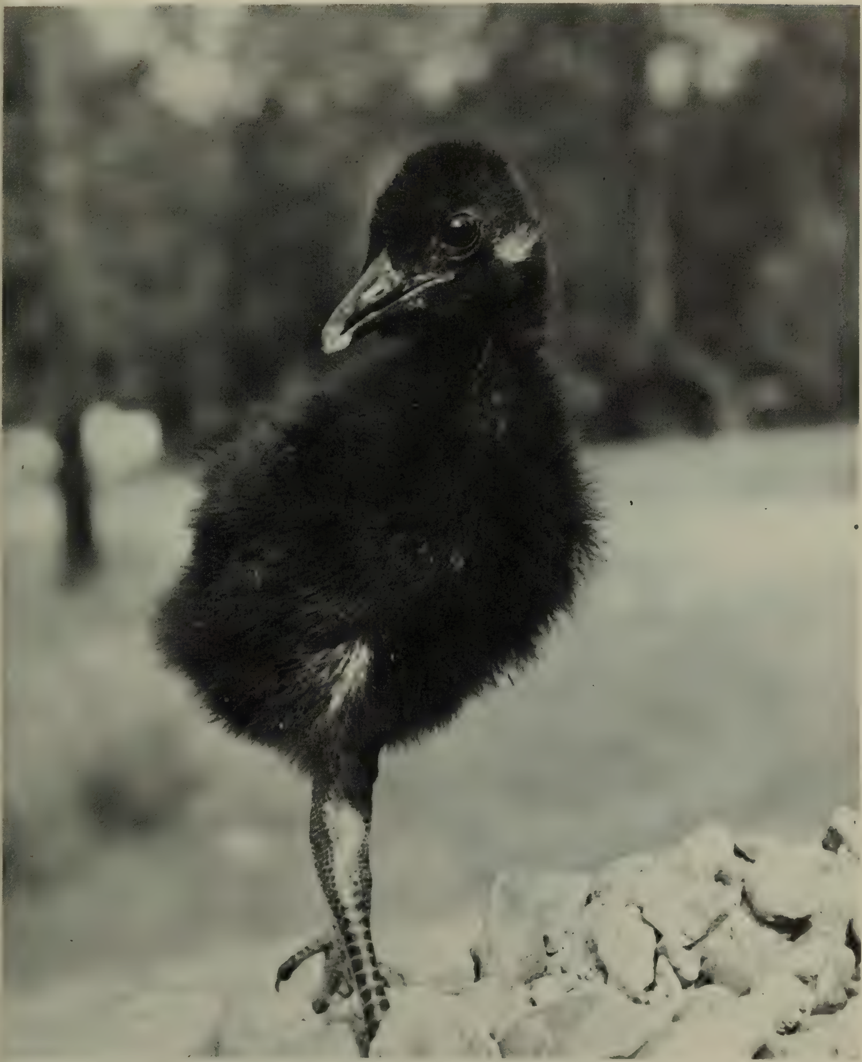

FIGURE 27.—Downy young King Rail, 31 days old, with juvenal plumage beginning to develop. White auriculars (of ear region) and white feathers of crural tract are visible; tip of bill and nares are white.

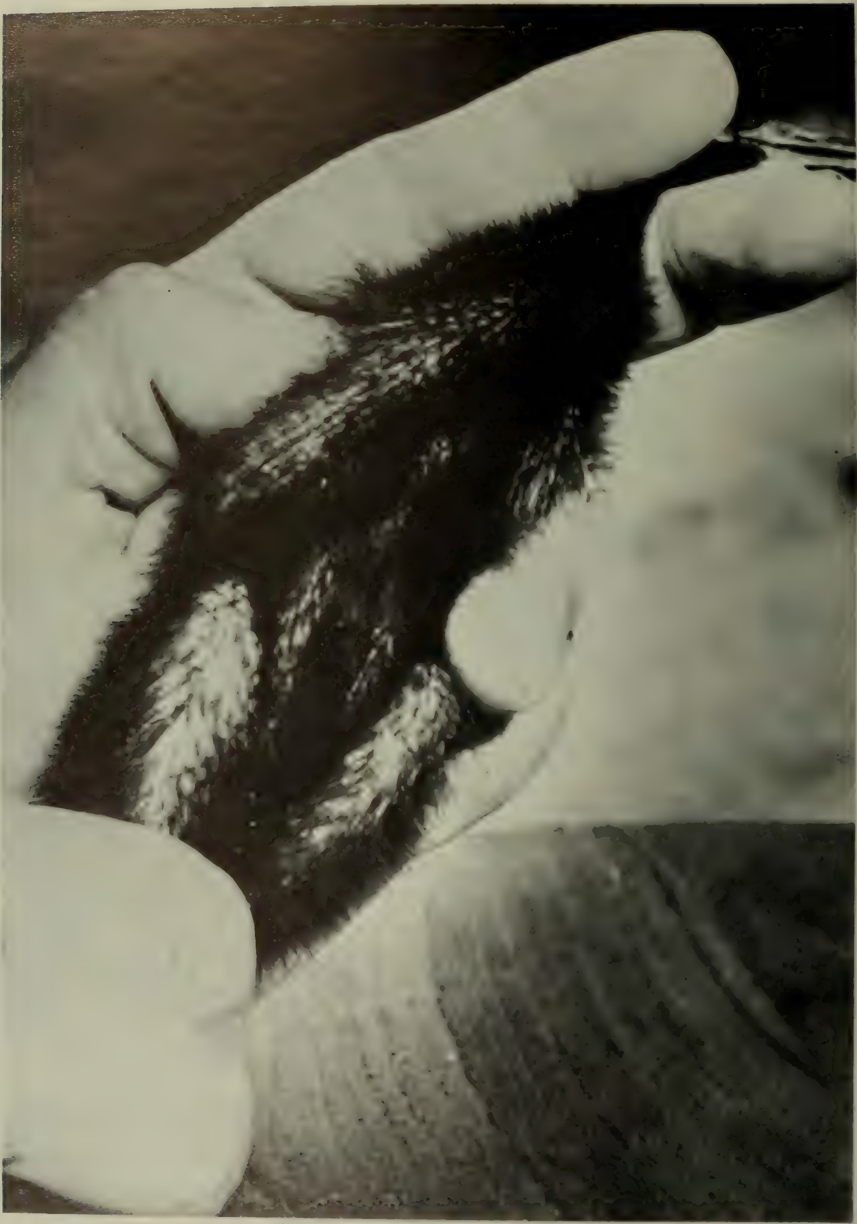

FIGURE 28.—Ventral view of 31-day-old King Rail showing development of white juvenal plumage in sternal and abdominal region and crural tract.

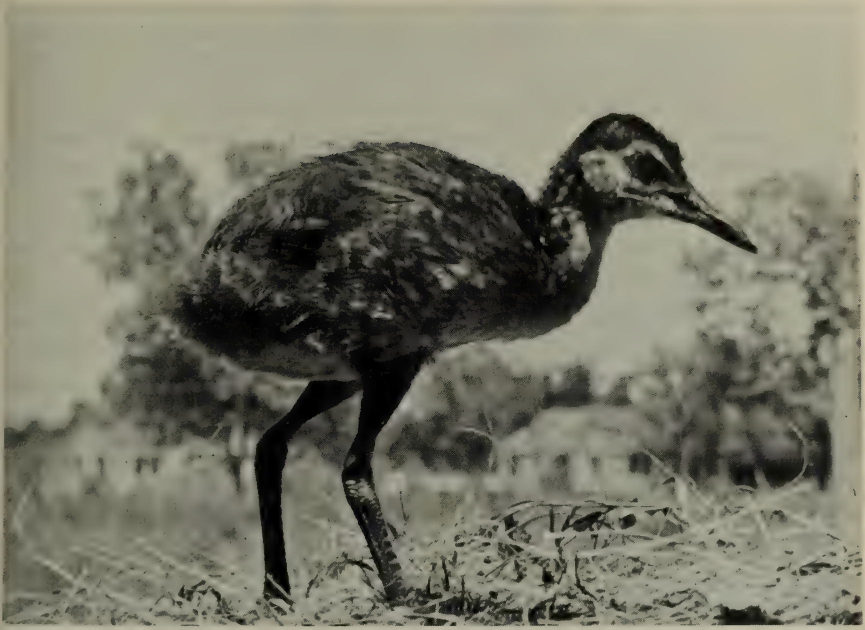

FIGURE 29.—Fifty-day-old King Rail with juvenal plumage nearly complete. Tail and wings are undeveloped. This individual is slightly behind the average for its age.

pear. The legs and bill approach flesh color, and the distal half of the bill is darker than the proximal half. The eyes have brown irides and black pupils.

By the seventh or eighth week the juvenal body plumage is almost completed, and the young King Rail has a more brownish and less dusky appearance (fig. 29). The cinnamon coloring of the lower throat and breast approaches that of the adult. The juvenal featherings of the crown and nape are complete, and the flight feathers and tail are well advanced on most birds.

There may be considerable variation in weight and size of young rails during the second month of development. At two months a captive male and two captive females weighed 327.0, 258.6, and 202.0 grams respectively.

The juvenal plumage is nearly complete by the age of 60 days. Remiges have developed enough so that some juveniles can make short flights after the ninth week.

Ridgway and Friedmann (1941, p. 84) have presented a detailed account of the juvenal plumage, as follows:

> Above similar to adult, dark phase, but the dark centers of the feathers of the back, etc., less fuscous, more dull black, the edges grayer and less well developed on the interscapulars and not at all developed on the lower back and rump which are uniformly blackish, the long scapulars being the only feathers with well-developed tawny-olive margins; lesser and some of the outer greater

upper wing coverts tipped with white and crossed by another narrow white band about 7 mm. anterior to the tip; sides of head as in pale phase adult, but the light ochraceous-buff areas cross-barred with narrow dusky lines (actually the tips of the feathers); lower throat pale, light ochraceous-buff narrowly barred with grayish hair brown to deep drab; anterior part of breast more heavily washed with pale ochraceous-buff; rest of breast and entire abdomen white, crossed by broad, closely spaced, but somewhat broken bands of grayish hair brown, the middle of the abdomen and lower breast unbarred; sides and flanks dusky grayish olive-brown barred with white or buffy white; thighs and vent like sides of breast but somewhat darker; under tail coverts and under wing coverts as in adult.

Call notes of young rails remain essentially the same during the second month of life as they were during the first month, but the voice becomes a little hoarser and deeper. During the second month the young rail frequently exercises by jumping up and down, flapping its wings at the same time.

The begging display may still be observed occasionally during the ninth and tenth weeks, but it soon disappears.

A considerable change in calls occurs during the ninth and tenth weeks. Some of them now approximate the calls of the adults. The call most like that of an adult bird is a raucous crying squawk or catlike "meow." This call is made when a bird is separated from the family group or is excited. The typical *jupe-jupe-jupe*-call of the adult was not heard until the fifth month.

First winter plumage

For most individuals the first winter plumage is similar to that of the adult. Some individuals, however, have whitish juvenal-like plumage of the underparts and less distinct markings about the face. Most rails in juvenal and first-winter plumage have some white barring on the wing coverts. This is also true of some adults.

MISCELLANEOUS NOTES ON BEHAVIOR OF YOUNG

Sleeping

From the time captive birds hatched until they were approximately a month and a half old, the three to six occupying the same cage slept together. Thereafter, as they assumed a somewhat different sleeping posture, they usually slept separately, but sometimes still slept as a group in the same part of the cage.

During the first 2 weeks after hatching, a warm quart-sized bottle of water was placed in the box with the downy young. When sleepy the chicks would huddle around the bottle, but not always in contact with one another. However, if the bottle was removed, the chicks huddled together when sleeping.

When just a few days old, chicks sleep in a prostrate position. They simply flop down on their bellies, usually with one side of their heads (cheeks) against the ground. Shortly thereafter, and until they reach the age of 1½ to 2 months, they assume a sitting posture for sleeping. Older young sleep more in the manner of adults, standing on one or both legs, with the head turned around and the bill tucked beneath the feathers of the back, or with the neck drawn in and the bill pointed down to the ground.

Competition

Virtually no peck order was exhibited by captive King Rail chicks during the first 2 weeks of life, when they fed together amicably in one area. Thereafter, they competed for food, and after obtaining a morsel from the common feeding site, would run away and ingest it or run around the cage for several minutes before swallowing it.

Because of size variation of individuals older than 2 weeks of age, there was an obvious peck order, but with little antagonism. A smaller or more agile chick often would not hesitate to steal a morsel from a larger competitor.

Bathing

When bathing, the King Rail assumes a partial squatting position. By an up and down movement of the legs, the body moves in one cadence, then the wings in another, and finally the head, dipping water and flipping it over the back, in still another. The body feathers are extended (somewhat ruffled), the closed wings are loose and moving, and the head is immersed while cocked sideways, presumably for more surface area, and hence functions better as a paddle in flipping water over the body. Water also reaches the plumage through the up and down action of the body and the movements of the wings. The bathing operation usually takes 1 or 2 minutes. A captive bird evicts another from the bathtub by pecking at its feet rather than at some other part of its body.

WINTER BEHAVIOR OF CAPTIVE RAILS

During extended freezes or when there is a snow cover, water for drinking is obtained by ingesting snow or small chunks of ice. Captive King Rails were observed ingesting snow and ice during periods of heavy snowfall and during freezeups in a cage on Bluegill Pond at the Patuxent Wildlife Research Center, Laurel, Md. One bird was observed as it ingested a chunk of ice 3 inches in length and ½ inch in width.

Captive King and Clapper Rails at Bluegill Pond preferred to rest on the ice rather than in a more protected section of the cage provided with a windbreak and a bedding of straw (fig. 30). During alternating periods of freezing and thawing, spherical chunks of ice, up to the size of a baseball, stuck to the tails of the Clapper Rails, and smaller particles stuck to their breasts. Strangely, particles of ice virtually never adhered to any part of the plumage of the King Rails.

FIGURE 30.—Captive King and Clapper Rails at Patuxent Wildlife Research Center, Laurel, Md., January 1960.

Foods

Crustaceans and aquatic insects are the preferred foods of the King Rail in most areas. Fish, frogs, grasshoppers, crickets, and seeds of aquatic plants also have a high palatability rating with this species. During the winter, particularly when the birds are hard pressed, considerable quantities of grain or some other vegetable matter may be consumed. In the southeastern Arkansas rice country, domestic rice formed 30 percent by volume of the King Rail's winter food. A stomach collected in December at Beaver Dam, Wis., was full of wheat. In South Carolina, Audubon (1835, p. 29) examined a gizzard crammed full of oats and collected King Rails in corn fields in autumn near Charleston.

Some unusual foods found in gizzards include cherry (*Prunus* sp.) seeds, skunk (*Mephitis* sp.) hair, feathers and vertebrae of a female Red-winged Blackbird, King Rail eggshell fragments, a small water snake (*Natrix* sp.), a mouse (*Peromyscus* sp.), a shrew (*Sorex* sp.), fall army worms (*Laphygma frugiperda*), blackgum (*Nyssa sylvatica*) seeds, acorns (*Quercus* sp.), and pine (*Pinus* sp.) seeds. A bird collected near Fleming's Landing, Del., on September 30, 1961, had its gizzard crammed with seeds of both waxmyrtle (*Myrica cerifera*) and bayberry (*M. carolinensis*).

The King Rail is more diversified in its choice of foods than its salt-water relative, the Clapper Rail, as might be expected because of its wider range and more variable ecology, which may find it feeding on the edge of a salt marsh along the coast or in an oat field a thousand miles inland.

Its adaptability to subsistence on a wide variety of foods in addition to its usual diet of crustaceans and aquatic insects enables the King to winter much further north than is generally realized. A King Rail observed by I. W. Knight at Lorne Park, Ontario, on December 26, 1960, remained in that locality until at least mid-January. It was seen along an open stream where it was observed feeding on a frog and the berries of "deadly" nightshade (Solanaceae) (Woodford and Burton, 1961, p. 326).

In some parts of its breeding range, particularly in brackish tidal-river marshes of the Middle and South Atlantic coast, the King Rail sometimes subsists largely on a 1-item diet, the red-jointed fiddler crab.

From 1959 to 1961, several hundred observations were made during the nesting season of King Rails feeding in brackish marshes along the Delaware Bay between Fleming's Landing and Woodland Beach, Del., where the red-jointed fiddler crab occurs in great abundance. This little crab formed the main diet of the rail; the only other item of any importance was a clam (*Macoma balthica*) (fig. 31). Stomach examinations confirmed field observations.

TABLE 12.—*Principal foods of 118 King Rails from Arkansas ricefields*

[Volume = percent of total volume of stomach contents. Occurrence = percent of stomachs in which found]

Food item	Collected in—								Annual volume, 118 stomachs
	Winter (Dec.–Feb.) 33 stomachs		Spring (Mar.–May) 48 stomachs		Summer (June–Aug.) 16 stomachs		Fall (Sept.–Nov.) 21 stomachs		
	Volume	Occurrence	Volume	Occurrence	Volume	Occurrence	Vol. ume	Occurrence	
ANIMAL:									
Invertebrate:									
Crayfish	7	18	61	81	22	25	3	5	23
Aquatic beetles	20	76	7	21	19	31	10	48	14
Land beetles	1	13	8	56	11	87	4	38	6
Grasshoppers	5	24	3	8	6	63	14	57	7
Aquatic bugs	5	24	1	15	10	44	6	29	6
Other insects	(1)	21	2	17	8	75	5	38	4
Spiders	(1)	3	(1)	2	(1)	13	1	10	(1)
Snails	3	12	2	8	(1)	6	(1)	10	1
Vertebrate:									
Fish	7	30	1	21	8	19	26	43	11
Frogs	5	21	4	15	5	50	4	24	5
Miscellaneous	5	7	6	8					3
Total	58		95		90		74		79
PLANT:									
Rice	30	52	4	19	10	31	21	29	16
Ricefield weed seeds	(1)	36	(1)	4	(1)	56	2	38	1
Woody plant seeds			1	2			3	10	1
Tubers	12	21							3
Total	42		5		10		26		21

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[1] Trace.

There is considerable variation in food items taken by different individuals in the same habitat and at the same time. Two birds collected from a tidal marsh on the Choptank River in Maryland in February 1961 present an interesting contrast. Bird A fed entirely on fish, while bird B ate a wide and rather unusual assortment of foods including the seeds of arrow-arum, hackberry (*Celtis occidentalis*), halberd-leaved tearthumb (*Polygonum arifolium*), dogwood (*Cornus florida*), and grape (*Vitis* sp.). Bird B had also eaten crayfish and a snail (Gastropoda). The seeds of arrow-arum contain calcium oxalate crystals and apparently are rejected by virtually all water birds except the Wood Duck (*Aix sponsa*). This was the only time I encountered them during my studies of rail foods.

Only in the Arkansas ricefields has a fairly complete seasonal survey of King Rail foods been made (Meanley, 1956, p. 252–258).

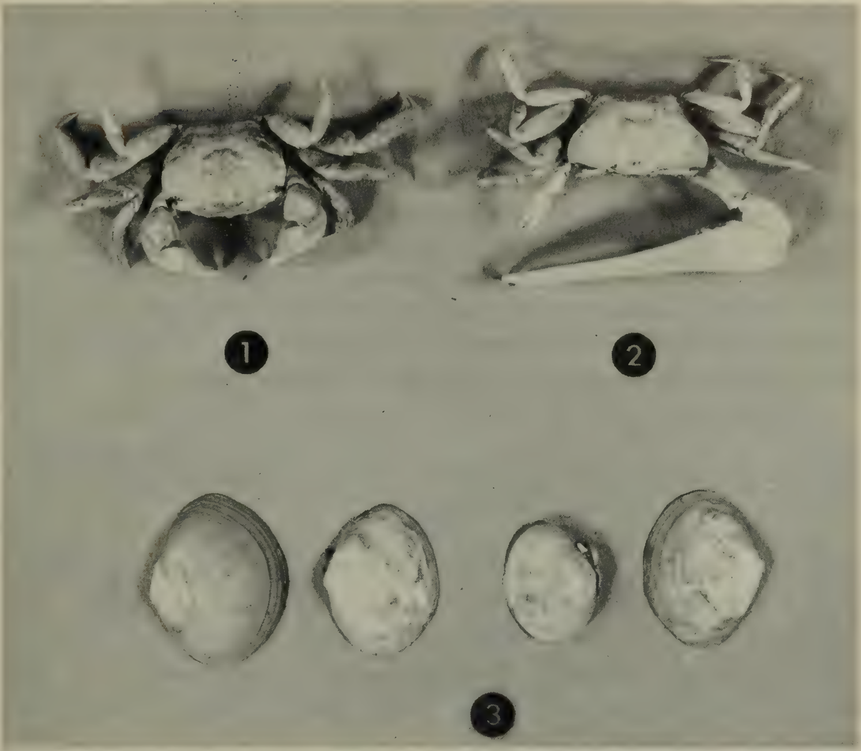

FIGURE 31.—Foods of the King Rail in brackish bay marsh, Broadway Meadows, Kent County, Del.: (1) Mud crab (*Sesarma reticulatum*); (2) red-jointed fiddler crab (*Uca minax*); (3) clam (*Macoma balthica*). (Photograph by Frederick C. Schmid.)

Small series of stomachs have been collected from a few other localities. Most of these were examined by John C. Jones of the U.S. Fish and Wildlife Service.

ARKANSAS RICEFIELDS

In the Grand Prairie rice-producing area near Stuttgart, Ark., 118 stomachs were collected between 1950 and 1955 by Karl Kitler and myself (table 12).

Animal life comprised 79 percent of the King Rail's annual diet. It constituted 90 percent or more in spring and summer, dropped to 74 percent in the fall (the largest number of stomachs were collected in November and may have made the figure lower than if there had been better representation of the early part of this season), and was still lower (58 percent) in winter.

The shift in feeding grounds from roadside ditches in the spring to ricefields in summer and early fall, and finally back to natural drainage ditches and small cattail marshes in winter, may account for some of the seasonal variations in diet. However, seasonal fluctuation in the abundance of aquatic animal life is apparently the basic explanation.

The crayfish was the principal food of the King Rail in the rice area, constituting 23 percent (by volume) of the annual diet; it formed 61 percent in spring; 22 percent in summer; 3 percent in fall; and 7 percent in winter. Since crayfish were available the year round, it appears that consumption of this crustacean was influenced as much by the availability of other favored foods as by the abundance of crayfish. Possible seasonal variations in the size, agility, and/or palatability of the crayfish according to age may have been factors bearing upon the extent of seasonal use by the King Rail.

Another staple food available at all seasons was fish, which composed 26 percent (by volume) of the diet in the fall when many fish had become impounded in the shallow borrow pits of drained ricefields and were easy prey for the foraging birds.

Aquatic insects were important foods, especially certain beetles and waterbugs which were available the year round. Predaceous diving beetles (Dytiscidae) furnished 19 percent of the winter diet.

Land beetles, chiefly ground beetles (Carabidae), scarabs (Scarabaeidae), and snout beetles (Curculionidae) made up 6 percent of the rail's annual food, while grasshoppers (Orthoptera) constituted 7 percent.

A wide variety of other insects were taken in small quantities. During the summer and fall they formed 8 percent and 5 percent, respectively, of the food. Among these insects were dragonfly (Odonata) nymphs, back-swimmers (Notonectidae), horsefly (Tabanidae) larvae, fall army worms, rice water weevils (*Lissorhoptrus simplex*), and rice stinkbugs (*Solubea pugnax*).

Frogs accounted for about 5 percent of the annual diet.

The King Rail apparently is more of a vegetarian than its salt marsh counterpart, the Clapper Rail. John Oney (1954, p. 23), in studying fall foods of the Clapper Rail along the Georgia coast, found that plant materials constituted only trace items of the Clapper Rail's diet at that season. Martin, Zim, and Nelson (1951, p. 82) found the volume of plant food in the Clapper Rail's diet to be 11 percent in winter, 1 percent in spring, 0 percent in summer, and 3 percent in fall. In the Arkansas area, vegetable matter in the diet of the King Rail made up the following volumetric percentages during the 4 seasons: 42 percent in winter, 5 percent in spring, 10 percent in summer, and 26 percent in fall.

Cultivated rice seed was taken in larger quantities than any other plant food, forming 16 percent of the annual diet. Increased consumption of rice seed during fall and winter was due in part to the abundance of waste grain left in the stubble. Kalmbach (1937, p. 60), in his study of the food of blackbirds in Louisiana, suggested that the hard siliceous hulls of rice seed may be used in the gizzard for grinding.

Ricefield weeds, abundant in all rail habitats, furnished some food through the year. Seeds of jungle-rice (*Echinochloa colonum*), wild millet, bullgrass, rice-cutgrass, beakrush, and smartweed (*Polygonum* spp.) were found as traces in many stomachs in each season except fall when they composed 2 percent of the contents.

The following seeds of woody plants were found in several stomachs: blackberry (*Rubus* sp.), snowball (*Styrax americana*), blackgum, and oak. Tubers of marsh plants, probably sedge (Cyperaceae), were found in several stomachs, and one rail had eaten tubers of an arrowhead.

TEXAS RICEFIELDS

Twelve stomachs were collected in ricefields at Eagle Lake, Colorado County, Tex., during September 1938 by Valgene W. Lehmann.

Three items formed the bulk (63 percent) of the food and occurred in at least half of the stomachs. The most important, the coneheaded grasshopper (*Neoconocephalus* sp.), occurred in nine stomachs and formed 30 percent by volume; dragonflies (Odonata) formed 20 percent by volume; and crayfish formed 13 percent by volume. An assortment of insects accounted for most of the remainder. Rice seed was the only plant food taken and comprised only 5 percent of the total food consumed.

LOUISIANA RICEFIELDS

Nine stomachs were collected in ricefields in the gulf coast region of Cameron and Vermilion Parishes in the summer of 1925 by E. R. Kalmbach and in 1955 and 1965 by myself.

Crayfish were in seven of nine stomachs and were the major item in six. Crickets (*Gryllus* sp.) were found in four stomachs and were the most important items in three of those. Weevils were the only other important food.

UPPER ST. JOHNS RIVER, FLA.

Six stomachs were collected in marshes in the Persimmon Hammock area during the spring of 1905 by W. W. Worthington.

Crayfish were the major items in five of the six stomachs. Short-horned grasshoppers (Acrididae) occurred in all of the stomachs, but were important percentagewise in only one. Aquatic and land beetles formed the balance of the food.

CURRITUCK SOUND, N.C.

Seventeen stomachs were collected, mostly in October, November, and December, 1909 and 1910, at Church's Island by J. B. White and W. L. McAtee.

Animal life formed 88 percent of the food with seeds of aquatic plants forming most of the balance. Important animal foods were sunfish (Centrarchidae) and perch (Percidae), grasshoppers and locusts, and aquatic insects (mostly Belostomatidae, Hydrophilidae, and Haliplidae).

PATUXENT RIVER, MD.

Six stomachs were collected in fresh tidal-river marshes along the Patuxent River in southern Maryland in early fall between 1923 and 1958, by O. J. Tremis, C. H. M. Barrett, and unknown rail bird hunters.

An interesting assortment of materials was found in this small series, including killifish (*Fundulus heteroclitus*), crayfish, dragonfly nymphs, snails (*Amnicola* sp.), grasshoppers, and crickets; leaves of a bulrush (*Scirpus* sp.) and rice-cutgrass; seeds of dotted smartweed, halberd-leaved tearthumb, arrow-leaved tearthumb (*Polygonum sagittatum*), burreed (*Sparganium eurycarpum*), water parsnip (*Sium suave*), silky dogwood (*Cornus amomum*), and wild cherry.

BEAVER DAM, WIS.

Eleven stomachs were collected in various marsh types during summer and fall, 1889–1908, by W. D. Snyder and C. F. Zimmerman.

Crayfish constituted over 90 percent by volume of the food in 6 stomachs and occurred in 9 of 11. Snails, soldier flies (*Odontomyia* sp.), dragonfly larvae, a mollusk (*Stagnicola palustris*), grasshoppers, and a fish (Etheostominae) were major items in the other four stomachs.

CHICAGO, ILL.

Five stomachs were collected during spring (April–May), 1912–17, by G. Eifrig and K. W. Kahmann. Crayfish were the major items (50 percent plus by volume) in four of the stomachs, and dragonfly nymphs were the major items (55 percent by volume) in the fifth. Stalks of a bulrush (*Scirpus* sp.) were important (40 percent by volume) in one stomach, and horsefly larvae were common (42 percent by volume) in another.

Two stomachs were collected during the summers (July) of 1878 and 1915 by S. A. Forbes and K. W. Kahmann. Frogs (*Rana* sp.) were the most important food (54 percent by volume) in one, and larvae of soldier flies (94 percent by volume) in the other.

Crayfish were a major item (45 percent plus by volume) in each of the three stomachs collected in the fall (September–October), one in 1913 and two in 1915 by K. W. Kahmann. Frogs (*Rana* sp.) were important (51 percent by volume) in one stomach.

Feeding Behavior

King Rails usually feed in areas concealed by plant cover or in comparatively open areas where they blend well with their surroundings and are only a few steps from cover. Sometimes, however, they are very conspicuous, as when feeding at low tide on mud flats or in open roadside ditches. Dawson (1903, p. 443) observed such feeding activity in Ohio:

> In a region where they were in little fear of molestation, I have seen them deploy upon an extensive mud flat in broad daylight and go prodding about in company with migrant sandpipers, for the worms which riddle the ooze with their burrows.

In tidewater areas, feeding probably occurs most frequently at low tide. Whenever I visit the brackish marshes of the Delaware Bay at ebb tide, I see King and Clapper Rails feeding in the tidal creek beds.

I suspect that King Rails do very little feeding at night, although they are sometimes active during this period, as they are occasionally heard calling, particularly during the courtship period. King Rails that I kept in captivity in Louisiana and Maryland were relatively inactive at night. In fact, some of them would habitually return to a favorite spot in the cage each evening at dusk, sit down, and remain quiet for long periods.

Generally King Rails forage in water so shallow that only the bill, or part of it, disappears beneath the surface while food is sought. However, on March 25, 1954, on the Arkansas Grand Prairie, I observed a pair of rails feeding in a roadside ditch where the water varied from 6 to 12 inches in depth. Both of these birds immersed their entire heads and necks in water, and several times their entire bodies disappeared beneath the surface. In fact, they occasionally fed by "tipping up" like dabbling ducks.

Since King Rails are accustomed to procuring their food from the water, if perchance they obtain a food item from land and are near an aquatic environment they usually carry the morsel to the water and immerse it before ingestion.

PELLET CASTING

Both the King Rail and the Clapper Rail, whose major food is crustaceans, reject most of the exoskeletal fragments of these animals through the regurgitation of pellets (fig. 32).

King Rail pellets examined in Arkansas and Maryland were composed of crayfish and aquatic insect fragments. Nearly every pellet

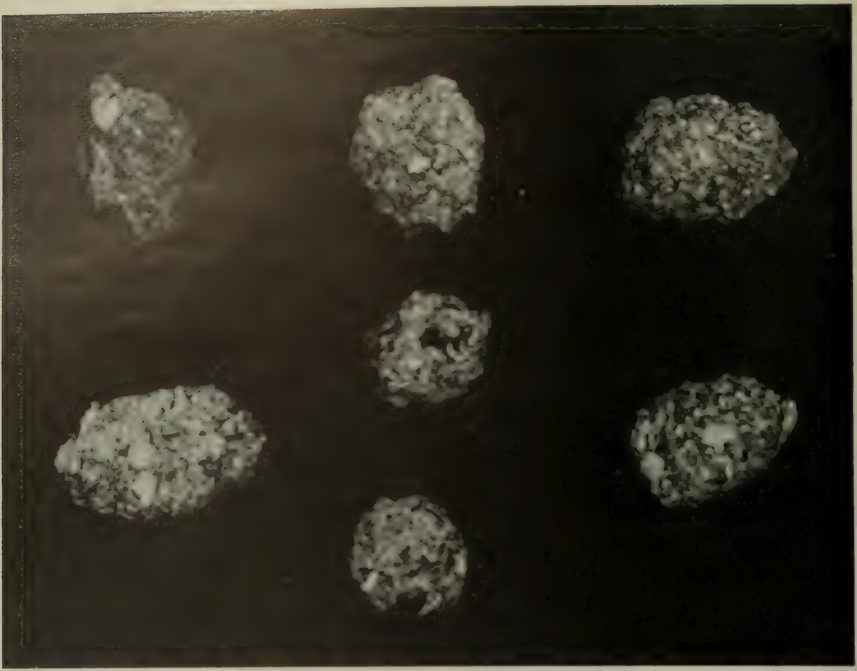

FIGURE 32.—Regurgitated King Rail pellets from Dorchester County, Md. Note the round gastroliths of the crayfish (*Cambarus* sp.) in top and bottom pellets at left. Pellets averaged 2 cm. in length by 1.5 cm. in width. (Photograph by Frederick C. Schmid.)

examined contained the hard cylindrical convex-shaped gastroliths of crayfish.

In brackish marshes near Woodland Beach, Del., where King and Clapper Rails occur together, pellets contained exoskeletal fragments of the red-jointed fiddler crab and a clam (*Macoma balthica*). As many as 14 pellets were found on a single muskrat house.

FEEDING YOUNG

I have observed King Rails feeding their chicks within 2 hours after hatching. Gross and Van Tyne (1929, p. 439) reported the same for the Purple Gallinule, another member of the family Rallidae.

When the very small young are abroad, they follow one or both parents about as food is caught for them. Larger food items such as crayfish and large grasshoppers are dismembered and fed to the young in pieces.

Sometimes, however, the young remain in a concealed place and wait for the parent to bring them food. At Grand Chenier, La., April 8, 1956, I observed a pair of adult rails for over an hour as they kept up a steady pace to and from a small pond catching fish and carrying them to young hidden behind tussocks of grass 30 or so feet distant.

Similar feeding was observed in a Louisiana ricefield where adults brought crayfish to young that remained in the same spot.

As the young grow older, they not only accept food from their parents but also begin to forage for themselves. An interesting example of this dual feeding activity was observed near Woodland Beach, Del., on July 29 and 30, 1959. An adult King Rail and three young approximately 5 to 6 weeks of age were observed feeding on clams at low tide in the bed of a creek. The adult bird dug in the mud for the clams, usually inserting its entire head beneath the surface. It would eat four or five clams and then carry one to the young. The clams were swallowed whole. Sometimes one of the young, standing next to its parent, would watch the digging operation and then start digging for itself. The parent and its young were seen digging for clams in the same place on both days. A raccoon also came to this spot and dug many clams.

REGIONAL OBSERVATIONS

Arkansas ricefields

During March, April, and May 1952 it was not unusual to see 15 or 20 King Rails in the evening feeding along ditches bordering certain highways leading out of Stuttgart, Ark. The variety of rail food available in these roadside ditches includes crayfish, tadpoles, frogs, aquatic insects, small fish, and snails. Toward the end of May the rails move out of the ditches and into ricefields, where they are found until harvest. During the winter they are found about the network of ricefield canals and natural drainage, often moving from place to place along runways beneath matted vegetation.

The King Rail feeds almost exclusively in ricefields during the summer. About the only time it emerges from this cultivated marsh type is to move from one ricefield to another. When a field of nearly mature grain is drained preparatory to harvesting, the rails move over to a field of younger rice which is often contiguous to the dry field. Some ricefields have a few low wet spots which prove attractive to rails, even up to harvest time; but the last feeding place in nearly all drying ricefields is along the "borrow" or ditch bordering the levees.

This typical bird of the rice country performs a service to the rice grower by consuming large numbers of crayfish that bore holes in the ricefield levees. A single large crustacean is usually torn apart and eaten in the course of several minutes; in one case the dismembering operation was timed at 7 minutes. Small crayfish are ingested whole.

Delaware Bay marshes

In the brackish tidal marshes between Fleming's Landing and Woodland Beach, Del., I have found King and Clapper Rails feeding in the same tidal gut. An important food of the rails here is the red-jointed fiddler crab, which is found further upstream than other species of fiddler crabs, but not far above the brackish zone and, as far as I know, not beyond tidewater in this area.

In some areas, fiddlers' holes or dens are concentrated mostly along or just beneath the top of the embankment of a tidal gut, and at high tide are inundated. Rails seem to feed mostly at low tide. When stalking fiddlers, rails are very slow and deliberate. When within striking distance, a rail makes a quick thrust or stab at the crab. When a fiddler is caught, it is often taken to some favorite feeding spot, such as a muskrat house or pile of drift debris, for dismembering. The large claw of the male crab is disengaged in the following manner, as described by Oney (1954, p. 24–25) for the Clapper Rail:

> The bird grasps the crab with its bill between the claw and the body. Then holding the crab, it vigorously shakes its head. The claw goes one way and the crab another. The bird then runs over and picks up the body and swallows it. The female crab does not get the same treatment because both of their claws are nearly equal size.

Some fiddlers, too large to swallow, are hacked to pieces and then eaten bit by bit.

Savannah National Wildlife Refuge

In early April 1960, I made observations of feeding King Rails along an alligatorweed-choked canal on the Savannah National Wildlife Refuge. Alligatorweed forms extensive mats upon which rails, gallinules, coots, herons, and several species of ducks do much of their foraging for aquatic insects, fish, tadpoles, frogs, and crustaceans. While this vegetation type has no apparent value in a waterfowl management program, it is of obvious value to birds that utilize its growth form to facilitate food gathering. Some King Rail feeding territories along the alligatorweed-choked canal were no more than 20 feet square, indicating the high rail-food productivity of these aquatic mats.

The most frequently observed pair of rails defended their feeding territory vigorously. Although they nested on the other side of the dike some 40 yards distant in a sawgrass marsh, they consistently returned to the same section of the canal for feeding.

The base of operations in the pair's feeding territory was a pile of debris, possibly an old alligator nest, at the edge of a small clump of giant cutgrass. From here the rails radiated out to feed on the mat of alligatorweed. Whenever a crayfish or some other large morsel was obtained, it was brought back to the pile of debris for "servicing" and eating. Old earthen dikes still much in evidence throughout the abandoned ricefield marshes of the Carolina Low Country are also used for this purpose.

Along the low banks of the canals, and sometimes partially submerged in the alligatorweed, numerous alligators, some 5 to 6 feet in length, sun themselves on warm spring days (fig. 14). They lie motionless for several hours at a time, and if they move there is simply a splash and complete submergence. It would seem that, to a waterbird wading around in the canal, an alligator sunning along the water's edge would look like another one of the many logs lying half submerged in the alligatorweed. But this is not the case. Rails, gallinules, and other birds feeding in the canal recognize the alligator as an enemy and usually give it a wide berth. Sometimes, however, they feed to within 2 feet of an alligator before circling the animal or retreating.

SOME UNUSUAL OBSERVATIONS

A very unusual feeding performance was recorded by Earle McPeak (Trautman, 1940, p. 230) at Buckeye Lake, Ohio. On June 11, 1929, an adult King Rail was observed to uncover, break, and eat five eggs of a painted turtle (*Chrysemys picta*), which on the preceding day McPeak had watched the turtle lay in a hole and cover with earth.

Another unusual field observation concerned the capture and devouring of a Semipalmated Sandpiper (*Ereunetes pusillus*) by a King Rail. E. D. Greaves (Chamberlain, 1960, p. 443) reported this incident, which took place at Pea Island, N.C., May 22, 1960:

> The rail darted out of the grass, picked the sandpiper from a feeding flock and after stabbing it repeatedly, pulled it apart and devoured it.

In June 1960, at low tide in Taylor's Gut, Kent County, Del., I saw a King Rail pursue and peck at a 3-foot-long water snake (*Natrix* sp.) for a distance of some 50 feet. Finally, the snake stopped and remained motionless for about 2 minutes as the rail continued to peck at it. Eventually each took off in a different direction. Possibly the rail was chasing the snake out of its nesting territory rather than pursuing it for food.

At Grand Chenier, La., March 1956, I observed a rail catch a crab in an open spot in the marsh. As the rail headed for cover to feed on the morsel, it was harassed so much by a Boat-tailed Grackle (*Cassidix mexicanus*) that it surrendered the crab to the blackbird.

Nauman (1927, p. 218) reported the following unusual feeding activity which took place at his home in Iowa during a snow storm. On April 16, 1921, when there were 8 inches of snow on the ground, a King Rail was observed walking around on the porch picking up bread crumbs. Until the snow melted, it returned to the porch on numerous occasions to feed on crumbs.

At the Patuxent Wildlife Research Center, a captive 10-month-old female King Rail attempted to eat a mouse and choked to death.

Mortality Factors

The most important factors in mortality of King Rails are (1) striking (or being struck by) manmade objects and (2) predation. In recent years, pesticides may also have become an important factor. From time to time, hurricane-caused floods decimate coastal marsh populations.

MANMADE OBJECTS

Since King Rails are nocturnal migrants, they strike various illuminated objects such as television towers, ceilometers, tall buildings, and lighthouses. On their breeding grounds in the southern rice belt, I have found dead King Rails under telephone lines and impaled on barbed wire fences.

The automobile is an increasing hazard because of the network of roads in the intensively cultivated rice country and the marshland of the South Central States. Over a 3-month period (March 1–June 1, 1952), I found 24 dead adult King Rails along a 10-mile stretch of paved road leading north from Stuttgart, Ark.

During floods in the gulf coast marsh country of Louisiana, King Rails and other water birds are literally flushed out of the marshes to the nearest high ground, which is often a well-traveled highway. During one period of high water in the marsh bordering the highway between the Intracoastal Canal and Creole, La., I saw 30 King Rails (mostly adults with broods) walking back and forth across the road in the face of heavy traffic. Many were being killed, particularly the young.

Wherever muskrats are trapped, King, Virginia, and Sora Rails become casualties since they use the runways where the traps are placed. Whenever I have encountered muskrat trappers in the course of my travels from New Jersey to Louisiana, I either have seen King Rails removed from traps or have been told of the many that are caught incidental to muskrat trapping. One trapper encountered in Maryland caught 50 King Rails during the course of a single trapping season (2½ months).

PREDATION

Judging from the many examples of predation in the literature, the King Rail appears to have a wide variety of natural enemies. Fur bearers are probably the most important, chiefly the raccoon, because of its fondness for eggs, and its abundance in most marsh habitats.

At a Lonoke, Ark., fish hatchery two rail nests found along the edge of a pond had been broken up by raccoons as evidenced by numerous tracks leading from the nest to a point in the open where the eggs had been taken and destroyed.

The mink may also be an important predator of this rail. The Rev. John Bachman, pioneer naturalist from Charleston, S.C., was quoted by Audubon (1835, p. 29–30) regarding the fate of the King Rail as follows:

> Its feathers are frequently found lying on the banks of rice-fields, ponds and lagoons, in places where the tracks of the minx plainly disclose the plunderer.

Similarly, on the Arkansas Grand Prairie, a mink trapper told me of finding typical mink signs at freshly killed King Rails. In Currituck County, N.C., Kenneth Wilson (1954, p. 199–307) found six species of birds taken by mink, including the King Rail. Wilson also cited one case in which an otter (*Lutra canadensis*) ate one of these large rails.

Predation by a bobcat (*Lynx rufus*) was noted by Bachman and cited in Audubon (1835, p. 29–30) as follows:

> . . . while placed on a stand for deer, I saw a wildcat creeping through a marsh that was near to me, evidently following by stealthy steps something that he was desirous of making his prey. Presently he made a sudden pounce into a bunch of grass, when I immediately heard the piercing cries of the Marsh-Hen, and shortly after came passing by me the successful murderer with the bird in his mouth.

Tanner and Hendrickson (1956, p. 56) found a dead King Rail at the den of a red fox (*Vulpes fulva*) in Iowa:

> During May and June 1951, the den of a red fox on the research area was visited almost daily and the remains of prey brought to the den by the parent fox examined. The only rail seen at the den was an adult King Rail found May 12. Since this bird had not been present May 11, and obviously had been dead several days, it seemed likely that it had been found dead by the foxes and brought to the den as carrion. The carcass had not been mutilated.

Bachman (in Audubon, 1835, p. 29) also found remains of a King Rail in the stomach of a large moccasin (probably *Agkistrodon piscivorus*). Another ornithologist of the Charleston area, Arthur T. Wayne, also cited an example of cottonmouth predation on the King Rail (1910, p. 36):

> In the month of April, 1900, I was observing a nest of this species in a buttonwood bush, which was in a pond of water, and, about every other day, I waded into the pond to see how many eggs were there. About the 8th of May, I judged that the full complement of eggs would be completed, and upon visiting the nest in the afternoon, which was very cloudy, I saw what I supposed to be the bird incubating. But upon close inspection I was very much surprised to find that what I took for the bird was a huge Moccasin (*Ancistrodon piscivorus*), which I promptly shot. This snake had eaten all the eggs and perhaps caught the bird as the feathers were scattered around the nest.

John W. Aldrich (personal communication) collected a fox snake (*Elaphe vulpina*) that had several King Rail eggs in its digestive tract, in Little Cedar Point Marsh on Lake Erie in Ohio.

Alligators (*Alligator mississipiensis*) are known to take King Rails. Kellogg (1929, p. 32) found remains of King Rails in 4 of 15 stomachs of alligators taken in Cameron Parish, La., in 1926.

Coulter (1957, p. 18) examined the gastrointestinal tracts of 157 common snapping turtles (*Chelydra serpentina*) from Maine marshes and found bird remains in about one of every four.

> Forty-two specimens contained evidence of a minimum of 52 birds including 25 ducks, 11 grebes, 3 rails and 13 unidentified birds.

No mention is made of the rail species taken. Birds the size of a King Rail could easily be taken by a large snapper. As an example, one 31-pound turtle consumed five birds including one Ring-necked duck (*Aythya collaris*), one Common Golden-eye (*Bucephala clangula*), and three Pied-billed Grebes (*Podilymbus podiceps*).

Hawks and owls take their toll of rails, gallinules, and coots. This is to be expected since virtually all birds of prey hunt in marshes as well as in uplands. Errington and Breckenridge (1936, p. 835) found the remains of a King Rail in a Marsh Hawk (*Circus cyaneus*) collected in August 1934 in the North Central States prairie region. Errington (1932, p. 182) also found remains of a King Rail in a Great Horned Owl (*Bubo virginianus*) pellet collected in April 1930 in southern Wisconsin.

The Fish Crow (*Corvus ossifragus*), well known as a plunderer of Clapper Rail eggs, is also known to take eggs of other rails. Frank C. Kirkwood and John Sommer found broken King Rail, Virginia Rail, and Least Bittern egg shells beneath an active Fish Crow nest at Gum Swamp Island, Blackwater Marsh, Dorchester County, Md., on June 16, 1929 (from Kirkwood's field notes, 1929).

HURRICANES

An interesting account of King and Clapper Rail behavior during a hurricane in the Louisiana prairie marsh country was given by Robert J. Newman (1957, p. 409), from information based on eye witness accounts of H. W. Belknap, graduate student from Louisiana State University, and J. H. Sutherlin, Manager of Sabine National Wildlife Refuge. Hurricane Audrey was Louisiana's worst coastal storm of the present century and struck with its greatest force along the southwest Louisiana coast on the morning of June 27, 1957. Newman's report was as follows:

> Rafts of marsh debris, ranging in size from 10×10 to 20×100 feet, went floating by (HWB, JHS). On them huddled a strange company of water moccasins, nutria, rails, and gallinules—sometimes as many as 20 birds to a raft. Occasionally as the great rollers surged forward, the mats of vegetation would buckle

and disintegrate. Then, according to Sutherlin, the Purple Gallinules would drown, but the supposedly less aquatic Clapper or King Rails would swim adeptly away through the rough water and flying spindrift.

The rain-drenched lawn at Sabine headquarters became a sanctuary within a sanctuary. The wildlife congregated there included water snakes, a marsh deer, a skunk, armadillos, and 200 to 250 King or Clapper Rails.

The King Rail as a Game Bird

Although a prized game bird, this large rail is seldom hunted because of the difficulty of maneuvering in its habitat, and the unlikelihood of finding concentrated numbers. Hence there are few localities where the King Rail can be considered an important game bird. In the gulf coast domestic rice producing areas of Texas and Louisiana, where King Rails are most numerous, they are probably shot in greater numbers than anywhere else; however, here considerably less than 1 percent of the local population is shot. In the Middle Atlantic States, the largest numbers are taken by hunters shooting Sora in the wildrice marshes of the Delaware Valley and Chesapeake Bay. However, in this area, some hunters will gun the wildrice marshes all season without seeing a King. Elsewhere in its range, the King Rail is shot only incidentally. Quail hunters in the South frequently encounter them and take a few.

Probably the best known hunting grounds in the Delaware Valley are in the wildrice marshes of Salem and Cumberland Counties, N.J. The tidal marshes of the Maurice and Cohansey Rivers in Cumberland County are famous rail hunting areas. The Patuxent River marshes near Upper Marlboro are the most important areas in the Maryland part of Chesapeake Bay; while in Virginia Tidewater, King Rails are hunted mostly along the lower James River in the upper reaches of some of its tributaries such as the Chickahominy; and along the Pamunkey and Mattaponi, famous Sora shooting rivers which downstream form the York. One of the most popular spots for King Rail shooting in Texas ricefields is the Eagle Lake area in Colorado County.

A few King Rails are killed by Clapper Rail hunters in coastal salt marshes. Hunters Tom Reed and Gordon Clark killed 3 Kings and 50 Clappers in 2 days of gunning at Chincoteague, Va., during September 1961.

In the open piney woods of Central Louisiana it seems odd to see a King Rail during the winter in some wet spot in the bluestem range. I know of several hunters in that locale who take one or two in each quail and woodcock season.

METHODS OF HUNTING

Contrary to popular opinion, the King Rail is not always an easy mark for the hunter despite its alleged weak flight. Characteristics of its habitat and other circumstances govern the manner in which it flies, and I have seen several fly at a fast clip for 300 yards.

The Marsh Hen, as this bird is sometimes called, tends to be secretive, but at times it is found in completely open situations near cover. It is not readily flushed, usually escapes by running, and flies only as a last resort. Flight begins with the legs dangling, but as the bird levels off, it flies in a straight line close to the ground with its legs extended straight back beyond the tail and its neck stretched forward.

Methods of hunting King Rails in the wildrice marshes of Chesapeake Bay and the Delaware Valley are quite different from those in the domestic ricefields of Louisiana and Texas. In the Chesapeake Bay and Delaware River tidal marshes, rails are hunted mostly from long, narrow, flat-bottom boats that are poled through the flooded wildrice beds by a "pusher" (figs. 33 and 34). When tides reach peak level, the rails flush as the boat approaches them.

Patuxent River, Md.

On the Patuxent River in the Southern Maryland tobacco country, rail hunting has been a sport enjoyed by the tobacco growing aristocracy since Colonial times. Perc Blogg (1944, p. 67–68), famous Maryland sportsman of the "good old days," presents an account of the hunting of Soras and King Rails on the Patuxent in his delightful

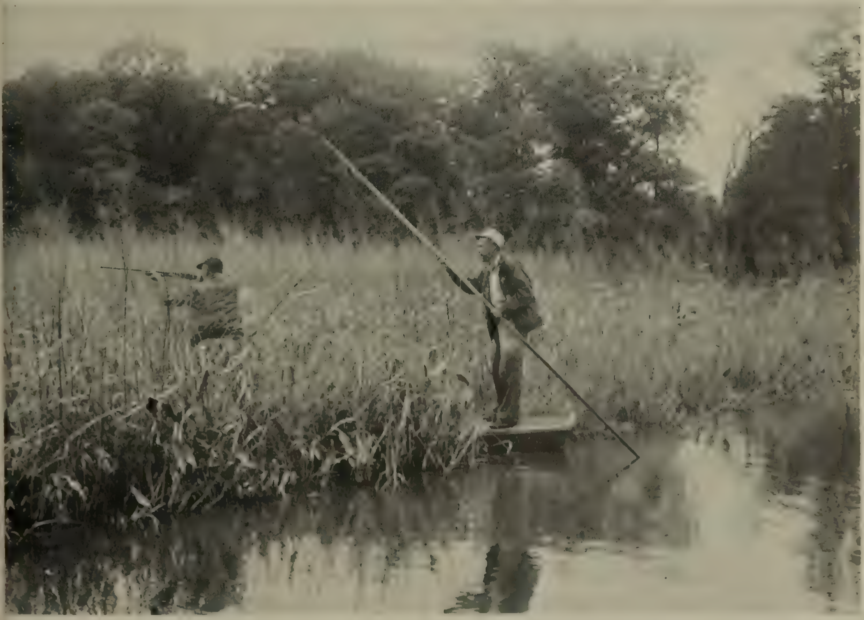

FIGURE 33.—Method of hunting railbirds in Patuxent River wildrice marshes in Maryland. Boat is poled through marshs at flood tide (September 1958).

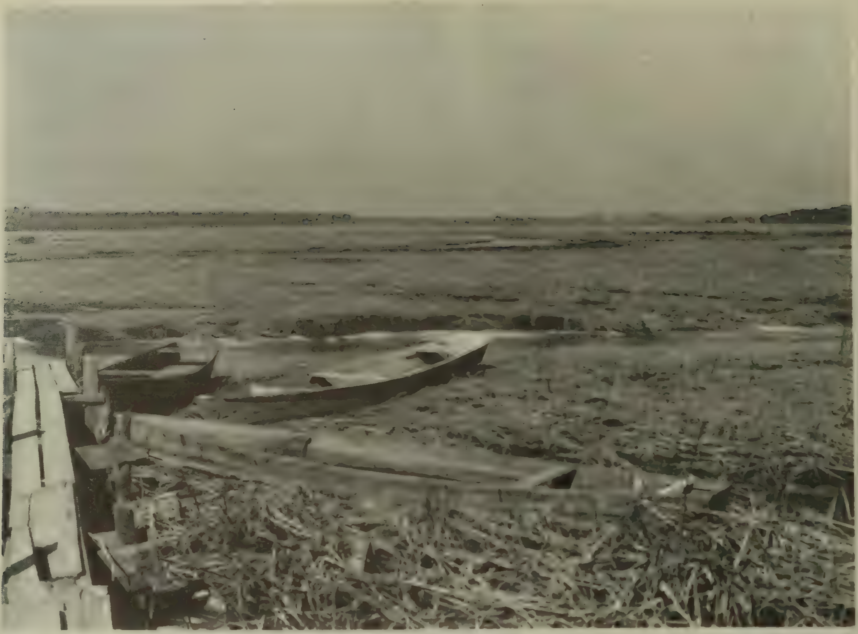

FIGURE 34.—After the hunting season: railbird boats tied up at dock in December. Low tide on old wildrice marsh on the Patuxent River in Maryland.

little book *There Are No Dull Dark Days.* He begins his essay with a poem about the Marsh Hen:

Give me a gun and some old Marsh
Where the pusher's voice calls mark right!
As the king rail springs from the ditch beyond
Then as suddenly drops out of sight.

"Dah he! Mark left!" What a thrill as the excited "pusher" calls the first bird on a beautiful September morn. This is the moment for which the gunnerman has waited many a month.

We are on the Patuxent. Everything has clicked; the wind is southeast and gentle, the day warm but not hot. . . . high tide at 7:30 a.m. As far as the eye can see on both sides of the river, artistic stalks of wild "oats" stand. Over on the higher marshes, a solid mass of brilliant yellow blossoms, called *butterweed* by the natives, greets the eye.

Rails, being in good requisition for the table, have been extensively hunted, particularly on the marshes of the Delaware and Chesapeake bays. Most sought after of the rails is the little sora or Carolina rail. The Virginia and king rail often add variety to the bag, however.

It is next to impossible to make these birds take wing when they are able to run. Because of this, rail are hunted only when the tide is so high that the flooded marshes afford no shelter and make it impossible for them to run. While the pusher poles a small skiff over the flooded marsh, the hunter stands in the bow, gun in hand. Every now and then a bird will jump, sometimes almost from under the boat, flying away with apparent feebleness, just over the tops of the foliage. As it flies, its legs dangle awkwardly. This ruse, however, is merely to prepare it for the sudden drop which often leaves the surprised hunter drawing a bead on empty space. Oftimes the gunner doesn't even see the rail announced by *Mark right, Mark left,* or simply "*Dah he goes.*"

On the Patuxent marshes in the 1940's, I would flush about 2 Virginia and 1 King to each 100 Sora.

Eagle Lake area, Tex.

The method of hunting King Rails in the Texas ricefields was described by Dev Klapp (1961, p. 14):

> On the Gulf Coast the rail is found in the great ricefields where it seeks its food. The close-knit rice stalks afford the bird ideal cover, and any attempt to hunt such terrain in an orthodox manner is next to useless. The hidden rail would merely sneak away as the hunter approached and never be seen.
>
> So Texans waste no time slopping around through ankle-deep gumbo mud chasing a bird that refuses to flush. They patiently wait until rice harvest time, then, by the hundreds they take to the fields.
>
> Beginning about October 1, reapers appear in the fields to gather the grain. The machines take positions at the outer perimeter of the fields and, as the sun rises above the horizon, go into action. Snorting and rocking, they circle the fields time and again, gradually working toward the center. Running side by side, usually in pairs, they cut a swath some 30 feet wide.
>
> The hunters wait until all but a 30-foot swath of rice is cut, then hurriedly take stands to each side of the uncut grain. In this narrow strip, they know, all the rail in the field are crowded. Reluctant to fly, the birds have crept through the standing grain, just ahead of the oncoming machines, until forced into this bit of cover.
>
> As the reapers get about half-way through this swath the birds begin to panic. That's when the fun starts. A hunter suddenly shouts, "There's one!" as the first rail rises from cover, almost straight up. Before the bird has set its course it is brought down.

The combine (fig. 35) has replaced the reaper in most areas, but the method of hunting is still the same.

Other areas

Milton B. Trautman (personal communication) reported that between 1907 and 1918 King Rails were hunted in the marshes of Indian Lake, Logan County, Ohio, and that bags of half a dozen birds a day were not uncommon. M. G. Vaiden, an ornithologist from Rosedale, Miss., told me that while Bobwhite hunting in the delta, January 30, 1945, he shot five King Rails and three Bobwhites; and on January 27, 1946, he shot four King Rails. The Rails were flushed from boggy spots in growths of ragweed (*Ambrosia* sp.).

In the days of the market gunner, rails were shot in much greater numbers than at present, and were sold in the markets of most of the large cities along the eastern seaboard. To the epicures, the King Rail of the fresh-water marsh was far superior to the Clapper Rail of the salt marsh. Charles S. Westcott ("Homo") writing in *Forest and Stream* magazine in the 1880's, said (Stone, 1937, p. 332):

> Many of the latter, however, carefully plucked were palmed off for King Rails on those less expert in identifying them.

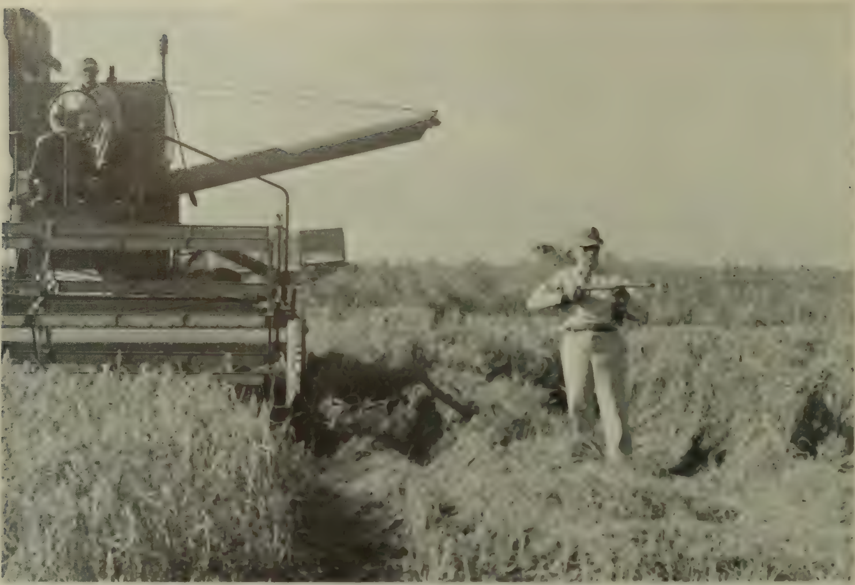

FIGURE 35.—Method of hunting railbirds in southern ricefields. As rice is harvested the hunter walks beside the reel of the combine which flushes the birds. (Arkansas Grand Prairie, September 1953.)

Summary

Audubon described the King Rail. Alexander Wilson and, for a while at least, Audubon considered it to be some form, perhaps an adult, of the Clapper Rail. Audubon and Bachman, staunch friends, spent a lot of time together in the Charleston area, where Bachman was able to show Audubon that the large rufescent rail was associated almost entirely with the fresh-water marshes and ricefields, while the "ash-coloured" rail was a denizen of the salt marshes. By so doing, Bachman apparently convinced Audubon that the two were distinct species.

The King Rail is essentially an inhabitant of fresh and brackish marshes, while the Clapper Rail is more an inhabitant of salt marshes. In some transition areas, however, particularly in the lower reaches of brackish river marshes, both species occur and sometimes interbreed. Viable eggs resulting from a mixed mating are known to occur, and some specimens taken in areas of interbreeding appear to be hybrids. Further study is necessary to understand more precisely the relationship between King and Clapper Rails.

Rallus elegans elegans is restricted mostly to the humid section of North America, east of the 100th Meridian. The Cuban form, *R. e. ramsdeni*, is restricted to Cuba and the Isle of Pines. A third form, *R. e. tenuirostris* (sometimes considered to be a race of *Rallus longirostris*), is restricted to the fresh-water marshes of the Valley of Mexico. In the United States the King Rail is found in greatest numbers in the South Atlantic and Gulf Coastal Plain provinces, especially in coastal fresh and brackish marshes and in ricefields.

While it has been shown that the King Rail is migratory, so few birds have been banded that little is known about the time, distance, and routes of migration. Apparently the major routes are along the Atlantic Coastal Plain and through the Mississippi Valley. Most birds probably arrive on the breeding grounds in the north during April and May and depart in August and September. Although most King Rails migrate to the South Atlantic and Gulf Coastal Plains in the fall, a few individuals may be found wintering almost anywhere within the geographic range of the species. Since there are numerous records of birds wintering in the middle and northern latitudes, it is not known whether birds seen in the spring are recent arrivals from the south or birds that have wintered in the area. Rails are very secretive in winter, becoming quite vociferous with the onset of the breeding season; thus spring arrival dates may be based on sighting or hearing of birds that have been present in the area for some time prior to the recorded date. During the summer King Rails may restrict their activities to a relatively small area for as long as 3 months, during which time the adults are nesting and molting, and the young, flightless for about 2 months after birth, are growing.

The 4,000,000-acre Louisiana coastal marsh is the largest block of breeding habitat in the range of the King Rail. The southern ricefields are a good example of an optimum breeding habitat. The breeding density of a King Rail population in a South Carolina river marsh was 25 males per 100 acres; in an inland Florida marsh the density was 30 males per 100 acres. King and Clapper Rails were found breeding in the same brackish marshes in Louisiana, Maryland, and Delaware.

King Rail sexes appear to be alike in plumage. The male averages larger than the female. Immature birds apparently can be externally distinguished from adults during the first autumn by the color of the soft parts. Most rails in juvenal and first-winter (immature) plumage have some white barring on the wing coverts. This is also true of some adults. The light-phase adult plumage described by Ridgway and Friedmann (1941) is probably typical of hybrids. The small sample of weights and measurements given in this report indicates that the King Rail averages slightly larger than the Clapper Rail.

Molt is not well understood. Apparently all individuals molt after the nesting season, but some also molt during it.

King Rails are known to return to the same section of the same marsh for several consecutive years to breed. Territories are established and maintained by aggressive behavior, primarily that of the male. The mating call, given by the male, presumably serves the same purpose as the song of a passerine bird on its territory, namely to attract a mate and to repel other birds of the same sex (but also, in the case of the King Rail, to maintain contact after pairing).

The display of the male during prenuptial courtship consists mostly in walking about with tail uplifted and white undertail coverts extended. After pairing, other forms of display and a repertoire of subdued calls are used to maintain the pair bond.

Copulation takes place near the nest site, before and during egg laying.

The nesting season of the King Rail is one of the longest among birds in the South. In Florida, there is evidence of nesting from January to July; and in Louisiana, from March to September. In the middle and northern latitudes the nesting season is usually about 3 to 4 months long.

Since the Clapper Rail in South Carolina is known to be double-brooded, it is possible that the King Rail in the southern part of its range may also have more than one successful brood; however, this has not yet been established.

Clutch size is large, averaging 10 or 11 eggs. There appears to be no geographic variation in clutch size.

Nesting success appears to be high in most areas. In one Arkansas sample, success was 75 percent; and in one Iowa sample it was 67 percent. Such success is probably due in some measure to the incubating birds' pugnacity toward would-be offenders. Survival of young until 2 weeks of age was about 50 percent in the Arkansas rice belt.

Downy young of the King Rail are black. A change from the downy plumage begins at about 1 month. Juvenal plumage is obtained in about 60 days, and wings are developed enough for short flights after the ninth week.

Usually chicks are more than 1 hour old before they can go over the nest and return. During the first month six different calls were recorded.

The King Rail occurs in a wider range of habitats and feeds on a greater variety of foods than most other North American rallids. Aquatic animals, particularly crustaceans, are its main food. Plant food items are taken more under emergency conditions. When the King Rail occurs in the same environment as the Clapper Rail, it may subsist mostly on a 1-item diet like that species.

In most areas King Rails feed mainly in shallow water where the depth is usually 2 or 3 inches. In Delaware Bay marshes, King Rails fed almost entirely on mud flats, exposed at low tide, and on the Arkansas Grand Prairie, in summer, they fed almost exclusively in ricefields.

In some areas King Rails were observed to have feeding territories to which they returned regularly at times other than the breeding season.

Most food items are ingested whole, but larger crustaceans often are dismembered before eating.

Mortality of King Rails apparently is due mainly to birds coming in contact with manmade objects, and to natural predation, especially the destruction of eggs by raccoons. Studies to determine the effects of pesticides on this rail have not been made; however, its favorite food, aquatic animal life, is highly susceptible to these chemical agents. In at least one intensive agricultural area, the Arkansas rice belt, where ecological conditions have not changed during the last 20 years, the King Rail has shown a marked decline.

The King Rail is one North American game bird that certainly is not overhunted. This is so primarily because the population is generally scattered and its habitat is usually difficult for hunters to work through. The only time that I found them concentrated and fairly easy to shoot was during the harvest in the Louisiana ricefields. A few are shot incidentally in the course of hunting Sora in the Middle Atlantic States, and Bobwhite in the deep South in damp piney woods.

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Appendix 1—Methods of Capturing for Banding

Most of the King Rails captured for banding have been taken in traps or with long-handled dip or clap nets. A few downy young have been caught by hand. Some King Rails are inadvertently caught in the course of trapping ducks.

TYPES OF CAPTURING DEVICES

Long-handled dip or clap net

This device is very effective in capturing King Rails on nests. Traps equipped with drift fences and placed in breeding territories will also capture rails during the nesting season as the birds wander about their territories. However, in such situations, where only one or two birds are involved, long-handled nets are more efficient because of the time required to install traps. Most incubating King Rails can be approached closely enough to be caught on a first attempt. The long-handled net I use has a bamboo handle 7½ feet in length, a hoop 2 feet in diameter, and a net 3 feet in depth.

Nest traps are effective in catching incubating King Rails, but are time-consuming to construct and are probably no more effective than long-handled nets. Blandin (1936, p. 62–63) described a nest trap for the Clapper Rail, a species that flushes more readily from the nest than does the King Rail.

All-purpose or cloverleaf trap

As nearly as I can ascertain, this is the type of trap most often used for capturing King and Clapper Rails (figs. 36 and 37). Seth H. Low (1935, p. 16–20) originally designed this trap for catching shore birds for banding. He used long leads or drift fences placed at right angles to the trap and running up to the trap entrance. Robert E. Stewart (1954, p. 1) caught nearly 1,000 Clapper Rails with this type of trap at Chincoteague, Va., and designed a very effective gathering cage that prevents rails from getting back into the trap (fig. 37). The effectiveness of Stewart's design is due to a ramp that begins at the opening at ground level and runs toward the top and rear of the cage. When a rail reaches the top of the ramp it drops down into a small chamber where it is well contained and easily retrieved.

The all-purpose trap used by Stewart and other Patuxent Wildlife Research Center biologists is about 6½ feet in length. Each of the two

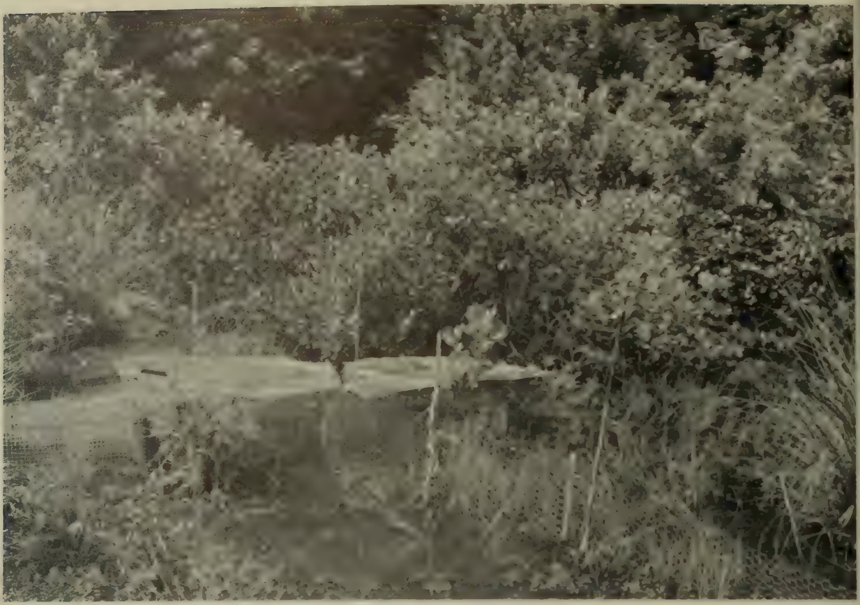
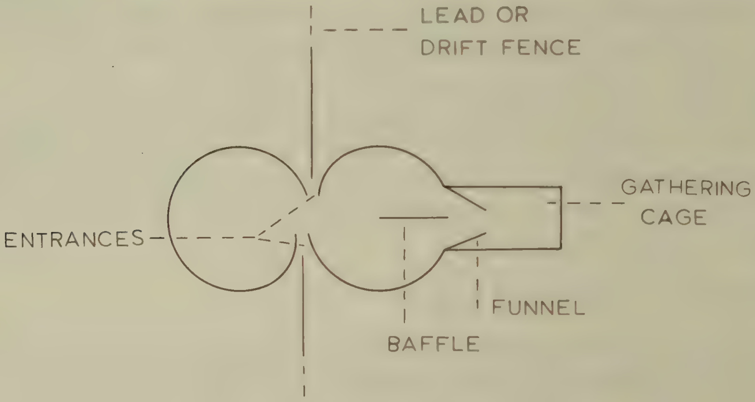


Figure 36.—All-purpose or cloverleaf trap and drift fence in shrub swamp at Patuxent Wildlife Research Center, Laurel, Md.



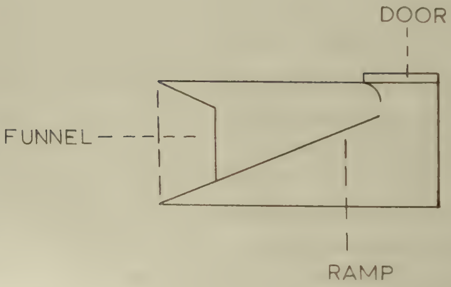


Figure 37.—All-purpose or cloverleaf trap.

cells is about 3 feet by 3 feet; flattened out, each cell section is approximately 9 feet in length by 1½ feet in width. The top is 7 feet by 4 feet.

The trap is best made of hardware cloth or welded wire. A less expensive and also less durable trap can be made of 1-inch poultry mesh (chicken wire). A trap made of poultry mesh should have a hardware cloth gathering cage.

The lead wire or drift fence should be a minimum of 1 foot in height. Two feet is better. One-inch poultry mesh is an ideal size for the drift fence. Downy young of banding age can probably get through a 2-inch mesh.

The length of the lead or drift fence depends upon the trapping situation. In marshy impoundments at the Patuxent Wildlife Research Center near Laurel, Md., I used some half-dozen different trapping designs at various times.

The trap is placed in that part of a marsh known to be inhabited by rails. Their presence is determined by hearing a bird call regularly from the same area during the course of several consecutive days, by locating a nest, or by hearing the cries of young that have been separated from their parents. The general area should be checked for tracks, droppings, and fragments of crayfish or other rail foods, and when tracks along a well-worn runway or path are found, the strategy then is to block it off with the drift fence.

Rails often feed along the edge of a marsh on a mud flat bordering open water. In such a situation, the drift fence should extend a foot or so out into open water and landward 10 or 15 feet (or more) to the trap. At low tide, in cordgrass marshes in Delaware, King and Clapper Rails feed along the exposed muddy bottoms of narrow creeks. In such a situation, a drift fence leading to a trap on either bank can be placed across the creek. Thus the rail's passage is cut off, and it tends to follow the fence toward the trap and often goes into it.

In a 10-acre shrub swamp-marsh mixture at the Patuxent Wildlife Research Center, the most select area for rails was in a 1-acre cattail patch. By placing four all-purpose traps about 30 feet apart in a row and connecting them with drift fences, I was able to block off an extensive area and succeeded in catching many rails (King, Virginia, and Sora). Numerous Common Snipe (*Capella gallinago*), Red-winged Blackbirds, Rusty Blackbirds (*Euphagus carolinus*), Swamp Sparrows and Song Sparrows were also captured. A few Wood Ducks, Woodcocks, American Bitterns (*Botaurus lentiginosus*), and Green Herons (*Butorides virescens*) were taken as well. The trap placed at the pond end of the cattail patch caught more rails than did the three in the interior of the patch.

TENDING TRAPS

The number of times a day that traps should be tended depends somewhat upon the size of the population in the area of interest and the frequency of catch. In high population areas, such as some Clapper Rail marshes, traps should be checked four or five times a day. In areas of low population, two or three times a day is adequate, as too frequent disturbance will frighten rails from trapping sites.

In areas of high predation by raccoons, opossums (*Didelphis virginiana*), minks, and domestic rats, it is well to leave traps open at night. When operating on a 24-hour basis it is important to check the trap at dusk or shortly thereafter. Rails left in traps at night in areas of high predator populations will almost without exception be destroyed. This is especially so because paths made by the operator seem to become natural highways for mammals.

Between dusk and dawn I virtually never caught rails (King, Virginia, or Sora) in traps at the Patuxent Wildlife Research Center. Most species of North American Rallidae are not as active at night as during the day. Some rails are vociferous at night especially during the breeding season; however, at that time they call mainly from territories.

When I first started trapping rails, I expected to encounter trouble with muskrats getting into traps. They do get into traps occasionally, but burrow out quickly, and I have never had to remove a single animal.

AGE FOR BANDING KING RAIL CHICKS

Downy young can be banded at 2 weeks of age, a few individuals as early as 10 days. The band size is number 5.

NEED FOR BANDING DATA

In view of the paucity of information on movements and population dynamics of rails, a large number of these birds should be banded. To accomplish this, it is necessary to know which methods are best for capturing rails, where to place traps, and in what geographic areas.

The all-purpose or cloverleaf trap with drift fences is the best known device for capturing rails for banding.

The best areas for trapping are usually determined by noting calls, reading "sign" (tracks, droppings, piece of discarded crayfish), and locating nests.

Localities in which I have found high populations are as follows: In Louisiana marshes near the intersection of the Intracoastal Waterway and the road to Pecan Island; just below the intersection of the Waterway along the road to Creole, and in a silted-in canal near Dulac; in marshes across the river (north) from Savannah, Ga.; and in marshes on the Savannah National Wildlife Refuge near Savannah.

Appendix 2—Local Names

The King Rail is probably better known in life to marsh hunters and trappers than to most ornithologists, and to these hunters and trappers it has its own special name depending upon locality. I picked up many of these names while working in the marshes and ricefields of the South.

Great Red-breasted Rail	Audubon (1835, vol 3, p. 27).
Fresh-Water Marsh Hen	Audubon (1835, vol. 3, p. 27).
Rale de Prairie	Creole hunters of Louisiana according to Audubon (Arthur, 1931, p. 235).
English Rail	Hunters on Arkansas Grand Prairie, Ark. (author).
Slash Guinea	Hunters on Arkansas Grand Prairie, Ark. (author).
Sage Hen	Southeastern Arkansas (Chicot County) rice farmers (author); also muskrat trapper, Rappahannock River, Va. (author).
Rice Guinea	Northeast Arkansas rice belt around Weiner and Hickory Ridge (author).
Rice Chicken	Northeast Arkansas rice belt around Weiner and Hickory Ridge (author).
King Sora	Potomac River, Va. (Kirkwood, 1895, p. 278); Powhatan River, Va. (author).
King Ortlan	Patuxent River, Md. (author).
King Water Rail	Muskrat trapper, Choptank River, Md. (author).
Marsh Pullet	Allen's Fresh, Wicomico River, Md. (author).
Mud Hen	New England (Forbush, 1925, vol. 1, p. 352).
Injun Hen	Raleigh, N.C., area (Brimley, 1887 p. 201).

Okankiskoki (ruddy raven)	Big Cypress Seminole Indians (Mikasukis), Florida (Gillespie, 1956, p. 123).
Oklani kahki (ruddy raven)	Cow Creek Seminole Indians (Muskogee), Florida (Gillespie, 1956, p. 123).
Marsh Hen	Many localities.
Stage Driver	Lake Erie marshes, Ohio (author).

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THE SEA OTTER
IN THE
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This publication series includes monographs and other reports of scientific investigations relating to birds, mammals, reptiles, and amphibians, for professional readers. It is a continuation by the Bureau of Sport Fisheries and Wildlife of the series begun in 1889 by the Division of Ornithology and Mammalogy (Department of Agriculture) and continued by succeeding bureaus—Biological Survey and Fish and Wildlife Service. The Bureau distributes these reports to official agencies, to libraries, and to researchers in fields related to the Bureau's work; additional copies may usually be purchased from the Division of Public Documents, U.S. Government Printing Office.

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THE SEA OTTER
IN THE
EASTERN PACIFIC OCEAN

By Karl W. Kenyon, *Wildlife Biologist*
Division of Wildlife Research
BUREAU OF SPORT FISHERIES AND WILDLIFE

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PREFACE

This report is the result of studies conducted from 1955 to 1967
the Division of Wildlife Research of the Bureau of Sport Fish-
ies and Wildlife. In addition to field data gathered primarily in
e Aleutian Islands, many unpublished reports, letters, and memo-
ndums in U.S. Fish and Wildlife Service files were used. As a
ologist working on studies of the Pribilof Islands population of
rthern fur seals from 1947 to 1955, I developed an interest in
e sea otters of the Aleutian Islands. I was therefore pleased to
assigned as project leader of sea otter studies.

Many people contributed help in the field and laboratory. The
llowing undertook special studies and have kindly permitted me
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The cooperation of Game Biologists of the Alaska Departme of Fish and Game was of particular value. Reproductive trac stomachs, other specimens, and information contributed by th furnished much of the material upon which this report is based

The Woodland Park Zoo, Seattle, and the Point Defiance Aqu ium, Tacoma, generously furnished facilities and care for capt otters and routinely recorded certain observations on behavi molt, and food consumption.

The help of Mrs. Ethel I. Todd, not only in typing the ma script but in assisting in many other phases of its preparati was indispensable.

All or a substantial part of the manuscript was read and edito assistance was given by P. A. DuMont, C. Larson, R. H. Manvi D. W. Rice, V. B. Scheffer, K. Schneider, D. W. Slater, and Wilke.

Weights and linear measurements of animals were taken either the metric or the English systems. The original measu ment is shown first, followed by the conversion in parentheses.

Nautical charts show distances in nautical miles (1 nauti mile equals 1.15 statute or land mile). In the present rep "miles" means nautical miles unless otherwise specified. Dep are usually given in fathoms (1 fathom equals 6 feet) because their use on nautical charts. Depths are given in meters w depth bears no particular relation to nautical charts. Maps adaptations from U. S. Coast and Geodetic Survey charts.

Trade names referred to in this publication do not imply dorsement of commercial products.

Much work on the biology of the sea otter remains to be d Many of the studies included in this report are preliminary proaches to subjects that will require years of future study.

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INTRODUCTION

As early as 1733, Spanish missionaries and explorers bartered r sea otter (*Enhydra lutris*) pelts with the Indians of Upper nd Lower California (Ogden, 1941). Apparently the high value f the skins in the Orient was unknown to them.

In 1741 Georg Wilhelm Steller was shipwrecked with the Bering xpedition on Bering Island of the Commander Islands. Here he bserved the sea otter and gave the western world its first scientific escription of the animal and its habits. After the remnant of ering's expedition returned with valuable furs and news of bundant otters and seals on the islands to the east, fur hunters rom Siberia, the Promyshlenniki, soon began exploiting Aleutian a otter populations.

In 1779, members of Captain James Cook's expedition to the orth Pacific sold in Canton otter pelts that they had obtained t Vancouver Island. The high value of the pelts on the Oriental arket soon precipitated a flood of fur hunters from America and urope. Thus began intensive exploitation of otters along the est coast of the United States and Canada. Unregulated hunting roughout the sea otter's range was incessant, and by the end of e 19th century the sea otter was extinct commercially and early extinct as a species. Highlights of this period are recounted context by Miller and Miller (1967).

Management of the sea otter as a valuable natural resource egan in 1911 when the remnant population was given Federal rotection. It was feared that after nearly 170 years of unregu-ted exploitation the species might not survive. The initial phase f Government control was one of complete protection.

In 1935, men of the U.S. Coast Guard saw many sea otters at mchitka Island, and in 1936, U.S. Bureau of Fisheries agents ere stationed there to guard against poaching.

In 1936 and 1937, expeditions under Olaus J. Murie of the U.S. ureau of Biological Survey conducted the first comprehensive iological inventory of what had become, in 1913, the Aleutian slands Wildlife Refuge (now a National Wildlife Refuge).

These expeditions were the first to reveal that otter populations t a number of islands were growing. During World War II, dditional population growth was observed.

On my first brief visit to Amchitka in the late fall of 1947 Dr. V. B. Scheffer and I found dead otters on the beaches. Elme Hansen, who was stationed there, found and sent us additiona specimens. These were mailed wrapped, without preservative inside weather balloons and, as the assistant who cleaned th bones, I had a strong and unforgettable introduction to th sea otter.

In the 1949–53 period, R. D. Jones, Aleutian National Wildlif Refuge Manager, observed winter "die-offs" at Amchitka. I 1950–51 he led an expedition there to capture and transplan otters to other areas. All captive otters soon died, and it becam evident to him that the sea otter adapted poorly to captivity unde field conditions. This experience demonstrated that until furthe knowledge of the animals' biological needs was gained, transplanting attempts would be futile.

As a first step toward a better understanding of sea otte biology, Dr. Robert L. Rausch went to Amchitka to study strande animals, dead or dying, and Drs. C. M. Kirkpatrick and D. E Stullken, with the aid of R. D. Jones, F. Wilke, C. J. Lensink, an D. Hooper went there in the winter of 1954 to study sea otte physiology and the responses of otters to captive conditions. Muc useful knowledge was gained through these studies, but failure o a further effort to transplant otters from Amchitka to the Pribilo Islands in March and April of 1955 showed that still more knowledge was necessary.

It was now clear that the species was no longer endangered Anticipating a public request that the resource be utilized, th second or long-term study phase of management was begun b the U.S. Fish and Wildlife Service in 1954 and 1955. An annotate account of field studies is in appendix I. Early in this period i became apparent that several island populations were at or nea maximum size and that experimental harvests could be made.

When Alaska became a State in 1959, the statehood act provide that jurisdiction over the exploitation of game and fur-bearin mammals, including the sea otter, should pass to the State.[1] Soo State officials decided to harvest sea otter pelts. The third phas of management began at Amchitka in the winter of 1962 whe an experimental harvest was taken by Alaska Department o Game and U.S. Fish and Wildlife Service biologists. Subsequen harvests were taken by State biologists at Amchitka in 1963 an

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[1] Federal regulations govern the exploitation of these animals on National Wildlife Refug lands but not in State waters adjacent to them. Thus, the sea otter is under Federal jurisdictio when it comes on shore on a National Wildlife Refuge and when it goes to sea beyond terr torial boundaries.

1967, and at Adak in 1967. One thousand pelts were available for the first public auction (since 1911) on 30 January 1968, at Seattle, Wash.

The harvesting of otters served the dual purpose of furnishing a financial return to the public and making specimens available for biological research. Many of the facts thus obtained are presented in this report.

Biologists of the State of Alaska, particularly K. Schneider, under the direction of J. Vania are progressing in management studies, especially in transplanting otters from areas of abundance to vacant parts of their former range. Concurrently, biologists of the State of California are studying the population there. In the Soviet Union, long continued sea otter studies, principally in the Commander and Kuril Islands, have added much to our knowledge. A comprehensive review of published information on the sea otter is given by Harris (1968).

Wise conservation practices based on biological knowledge will assure not only that the sea otter will once again be an article of commerce, but also that this interesting member of our wildlife community will flourish as an esthetically and scientifically valuable part of our environmental heritage.

SYSTEMATICS

Evolution

It has been supposed that the sea otter derived from an Atlantic Ocean early Pleistocene ancestor *Lutra reevei* (Newton) (Thenius and Hofer, 1960, p. 166). Recent findings in California of sea otter remains from the early and late Pleistocene demonstrate that this supposition is incorrect. Mitchell (1966, p. 1908) studied all available paleontological material. In his exhaustive review of the fossils and literature he stated:

> Because these older North Pacific fossils are considered to be conspecific with the living sea otter, it is obvious that the *Lutra reevei* tooth cannot represent a direct ancestor of *E. lutris*. . . . The sea otter may probably be considered as a strict North Pacific endemic autochthon, just as McLaren (1960) has assumed it to be.

Taylor (1914) studied the osteology and aquatic adaptations of the sea otter and the river otter and concluded that the two otters are fundamentally alike and probably descended from a common ancestral form. Because the fossile record is incomplete, it is possible only to speculate where the sea otter originated. Dr. Charles A. Repenning suggests (letter, 3 March 1965):

> I would guess that *Enhydra* developed from the otters of the Pliocene of India and eastern Asia and moved northward along the western shore of the North Pacific with the accentuation of global climatic zonality. All of the otters of North America (including *Enhydriodon)* seem to be derived from Asiatic stock and seem to have arrived in North America in the Pliocene and early Pleistocene.

Taxonomy

The sea otter is the only member of the genus *Enhydra.* It is the largest (to 100 lb. [45 kg.]) member of the family Mustelidae, which includes nearly 70 species—river otters, skunks, weasels, and badgers, among others. Unlike other mustelids, it has no functional anal scent glands. The sea otter is the most specialized of the group, being adapted to a narrow ecological zone in the marine environment. Besides being the smallest marine mammal, it is the only one in the order Carnivora. Among mammals it shares the marine environment with the pinnipeds (seals), cetaceans (whales and porpoises), and sirenians (manatees and dugongs).

Miller and Kellogg (1955) and Hall and Kelson (1959) recognize a northern race, *Enhydra lutris lutris* Linn., formerly ranging from Vancouver Island to the end of the Aleutian Islands chain, and a southern race, *E. l. nereis* Merriam, ranging from the Strait of Juan de Fuca southward, formerly into Baja California, Mexico. The southern race was described on the basis of one skull. Barabash-Nikiforov (1947) reviewed available data and says "we are justified in drawing conclusions on the sea otter based on the slight amount of material we succeeded in collecting." He recognized three races: *E. l. lutris* Linn., "the Commander-Aleutian North American sea otter"; *E. l. gracilis* Bechstein, "The Kuril-Kamchatka sea otter"; and *E. l. nereis* Merriam, "southern California sea otter."

After superficial examination of several hundred sea otters taken at Amchitka Island (as mentioned elsewhere), and after observing the variation in color and body size among animals of this local population, I agree with Scheffer and Wilke (1950). They studied specimens from California and the Aleutian Islands and reviewed the basis for establishing a racial division. They concluded that "Neither on the basis of demonstrable variation nor on the grounds of geographical isolation is there support for a southern subspecies of the sea otter."

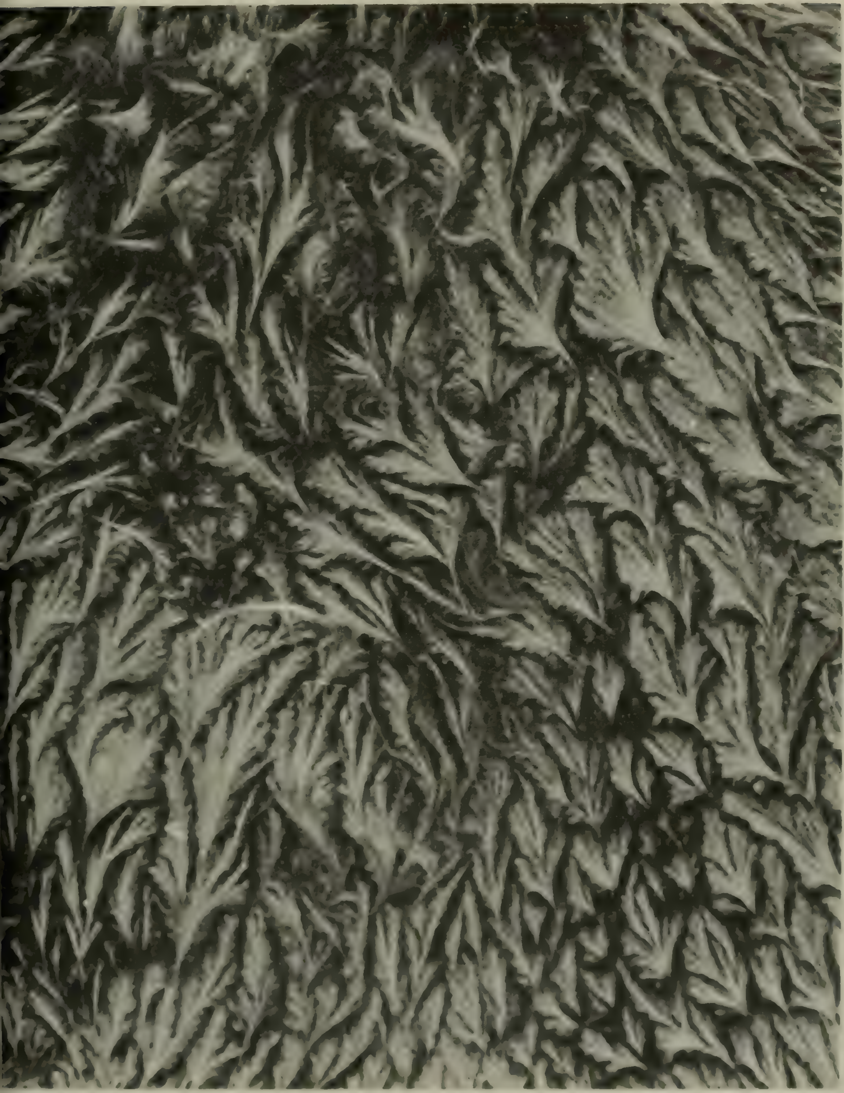
A careful study of specimens from the several geographical areas occupied by sea otters is now required before any racial differences in these populations can be recognized. Because of the variation among animals I have seen, the meager specimen material used to date in defining races, and the similarity of habitats occupied by the sea otter throughout its geographic range, it is not possible, without further study, to distinguish racially distinct populations which might exist.

PHYSICAL CHARACTERISTICS

The sea otter's characteristics include the following: (1) A coat of sparse guard hair and dense insulating fur which protects it from cold as blubber insulates other marine mammals. A blanket of air remains trapped at all times among the fur fibers of the sea otter so that the skin is never touched by the water of its chilly environment (fig. 1). (2) Flattened hind feet or flippers for propulsion. (3) Retractile claws on the front feet (fig. 2) (but not on the hind feet), the only member of its family so adapted. The forepaws are used to groom the fur, to gather and grasp food, to break the shells of mollusks and crustaceans against a rock held on the chest, and to pass food to the mouth. (4) A loose flap or pouch of skin under each foreleg, extending partially across the chest, is used to hold food organisms after they are gathered from the bottom until they are consumed while the otter floats on its back at the surface. In the wild it never voluntarily consumes food on land. (5) Flattened and rounded molar teeth having no cutting cusps. These are used to crush the shells, external skeletons, and flesh of food organisms. (6) A horizontally flattened tail aids propulsion. (7) A manner of swimming under water, similar to cetaceans, by means of vertical undulations of the hind flippers and tail. (8) An external ear (fig. 3) that resembles the ear of an otariid or eared seal more than it does the ear of a land carnivore or of its closest relative, the river otter.

The body of the sea otter is relatively long and heavy, making progress on land clumsy and slow. Although highly adapted to the marine environment, the sea otter is specialized to occupy the narrow zone of shallow water near shore. Apparently it cannot (or at least is not known to) obtain pelagic food where the sea is deep. It does not undertake seasonal migrations. If removed from its natural environment, i.e., water, and kept in a dry pen it shows great distress, perhaps because it instinctively senses that its fur may become soiled and through eventual wetting cause chilling and death. Also, in captivity when water is not available, heat prostration and death may occur unless environmental temperatures are carefully controlled.

At birth the sea otter is covered with dense brownish fur and long silky yellowish-tipped guard hair. The head is a light buff



'IGURE 1.—Pelage appearance shortly after a sea otter emerged from the water and shook himself. Only the tips of the fur are wet and thus stick together to form points. Beneath, the underfur is dry, insulating the otter's skin and enabling it to maintain its body temperature. (KWK 59–8–1)

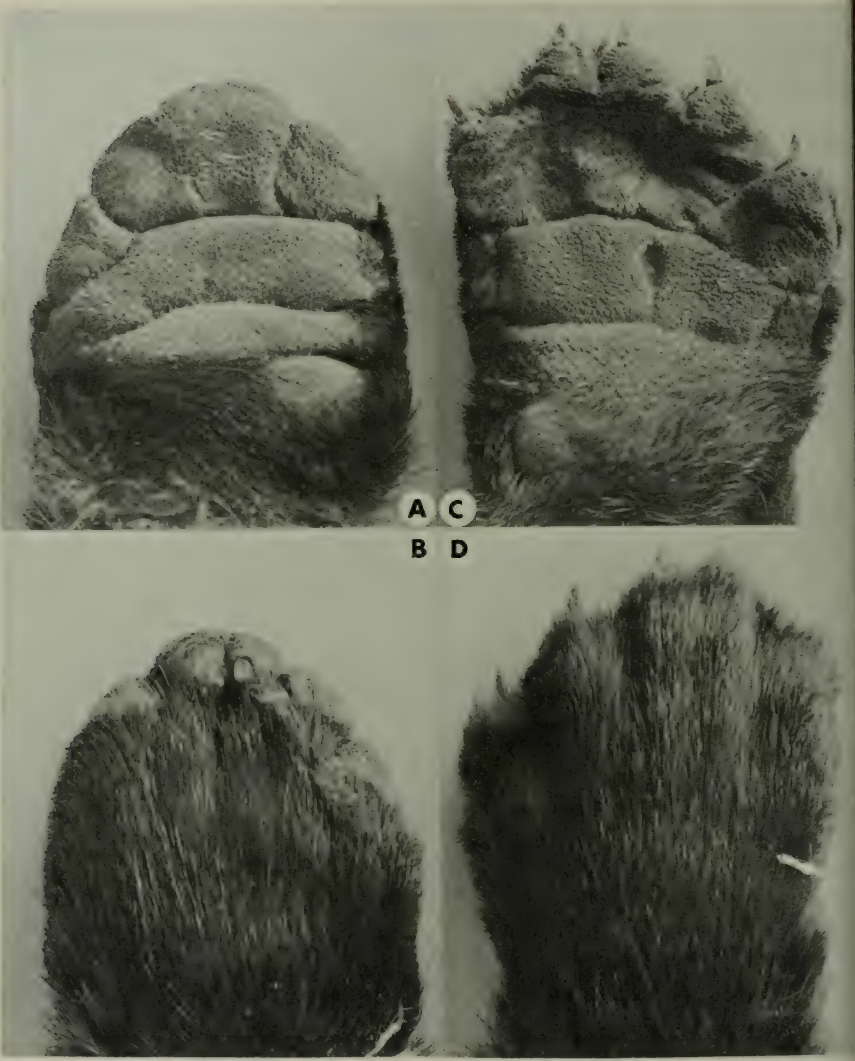


FIGURE 2.—Front feet of the sea otter. In the relaxed position the claws ar retracted (*A* and *B*). The claws are extended (*C* and *D*) during feedin when food is grasped and, with the help of the teeth, torn into small bite sized chunks. Much grooming is done with the claws retracted, but occasionally during this activity they may be extended. Note that the third an fourth digits are closely joined. The paws are highly sensitive. When a otter grasps a human finger between its forepaws, the mobile digits ca be felt moving like fingers inside a mitten. (KWK 64–1–8)

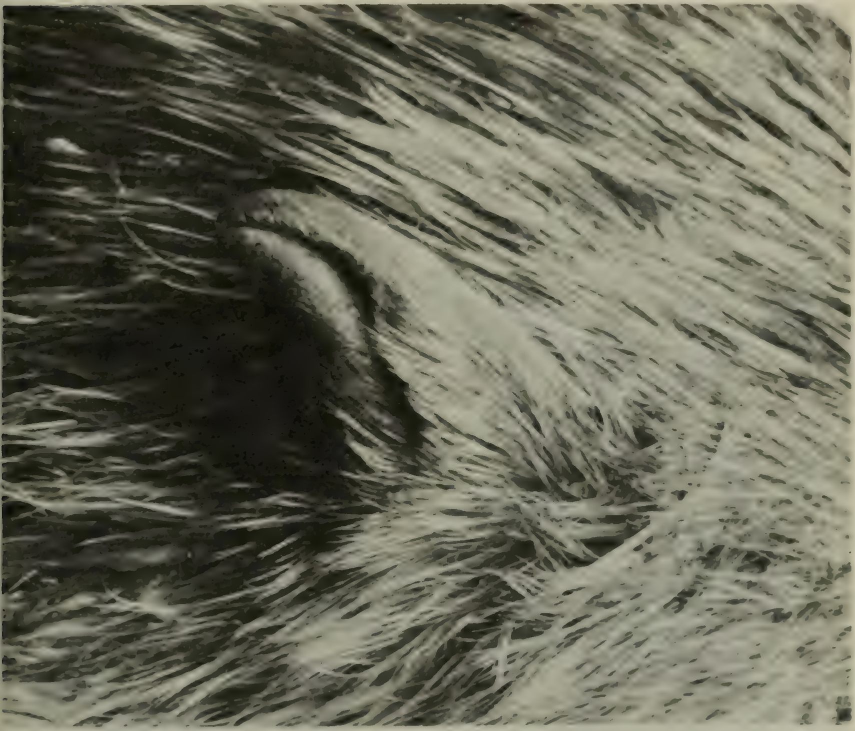


FIGURE 3.—The external ear of the sea otter resembles the ear of an otariid seal. It is cartilaginous and thickened but not as pointed at the tip or as tightly rolled and "valvelike" as the ear of a seal. The ear length (from notch) of an adult male was 32 mm. and of a subadult female 30 mm. While the otter is beneath the water the ears are pointed sharply downward. When the head is above the surface the ears are usually held erect. (KWK 61–42–0)

color (fig. 4). Over a period of several weeks the guard hair grows out, often giving the pup a distinctly yellowish appearance.

The late juvenile pelage is similar to that of the adult, which is typically dark bodied and buffy to light gray headed. The head tends to become whiter with age, and grizzling may appear on other parts of the body. Body color varies from light buff (rare) through shades of brown to nearly black. The sparse guard hair may be dark or silvery white.

IDENTIFICATION OF THE RIVER OTTER AND THE SEA OTTER

The river otter *(Lutra canadensis)* is often seen swimming in salt water in coastal areas of the Pacific Northwest and Alaska.

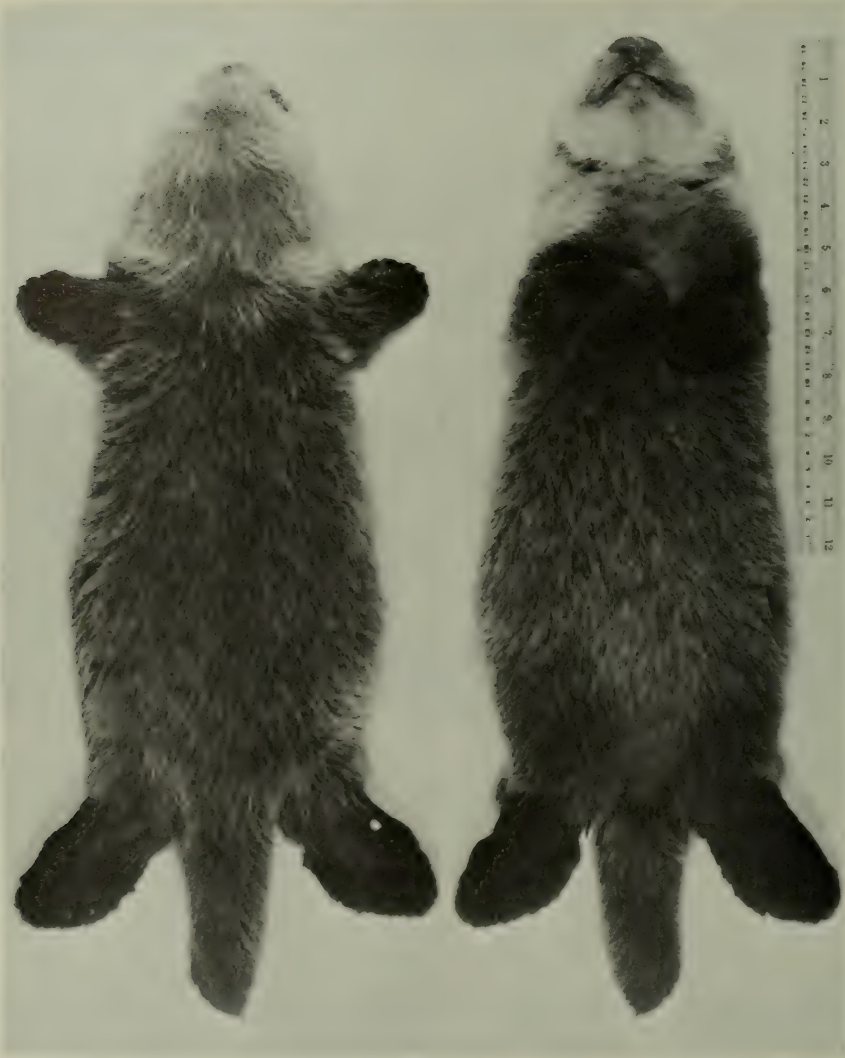


FIGURE 4.—Dorsal (left) and ventral (right) views of a newly born female sea otter taken on 6 April 1949 on Amchitka Island; weight 1,950 g. (4 lb. 6 oz.), length 560 mm. (22 in.); specimen BDM 378. The long, silky, yellowish-tipped natal pelage of the body and typical light buffy head and neck are demonstrated. The nearly black fur of the feet is soft and wooly. (KWK 500 and 501)

or this reason, observers often report the presence of sea otters hen they have actually seen river otters. To help in correct entification of these two species, the following comparison of agnostic physical and behavioral characteristics is presented see also figs. 5 and 6):

ield observation

a Otter

Occurs in Alaska from Prince William Sound, along the Alaska Peninsula, the Aleutians, and near Monterey, Calif. Is currently extending its range d should be looked for in Pacific coastal areas.

Found along open-sea coast in salt water only.

On surface usually swims belly up, forepaws on chest while paddling ith hind flippers. Floats high in water.

Clumsy on land, seldom seen on shore except in isolated Alaskan areas.

Eats while floating on back, never eats on shore.

Sleeps (usually) in kelp beds or calm water while floating on its back g. 7).

Bears single young which is carried on the mother's chest as she swims her back.

iver Otter

Occurs on rivers and along seacoasts in the United States, Canada, and laska. Often swims several miles in salt water between islands.

Found in salt or fresh water.

On surface usually swims belly down, back nearly submerged.

Agile and graceful on land, often seen on land.

Brings food ashore to eat.

Sleeps on land, usually, in dens, never while floating on its back.

May have up to four young, does not carry them on chest while swim-ing.

ecimen Observation

a Otter

Maximum weight 100 lb.

Maximum length 58.25 in.

Fur long and soft, guard hair delicate and sparse.

Claws of forepaws short and retractile.

Hind feet decidedly flipperlike and webbed to tips of toes. Pads visible ly at tips of toes (fig. 8) The fifth or outer digit is longest (fig. 9).

Tail somewhat flattened and does not thicken markedly at base, less than of body length.

Eyes are open at birth.

Last upper molariform tooth broad and flattened, about ¾ inch or more greatest width.

Baculum of adult about 6 inches in length (fig. 10).

ver Otter

Maximum weight 30 lb.

Maximum length 50 in.

Guard hair coarse and dense, covering fur completely.

Foreclaws long and not retractile.

Hind feet webbed but not flipperlike. Pads cover much of palm and digits. e fifth digit is not elongated.

Tail nearly round in cross section and heavily thickened at base, more an ½ of body length.

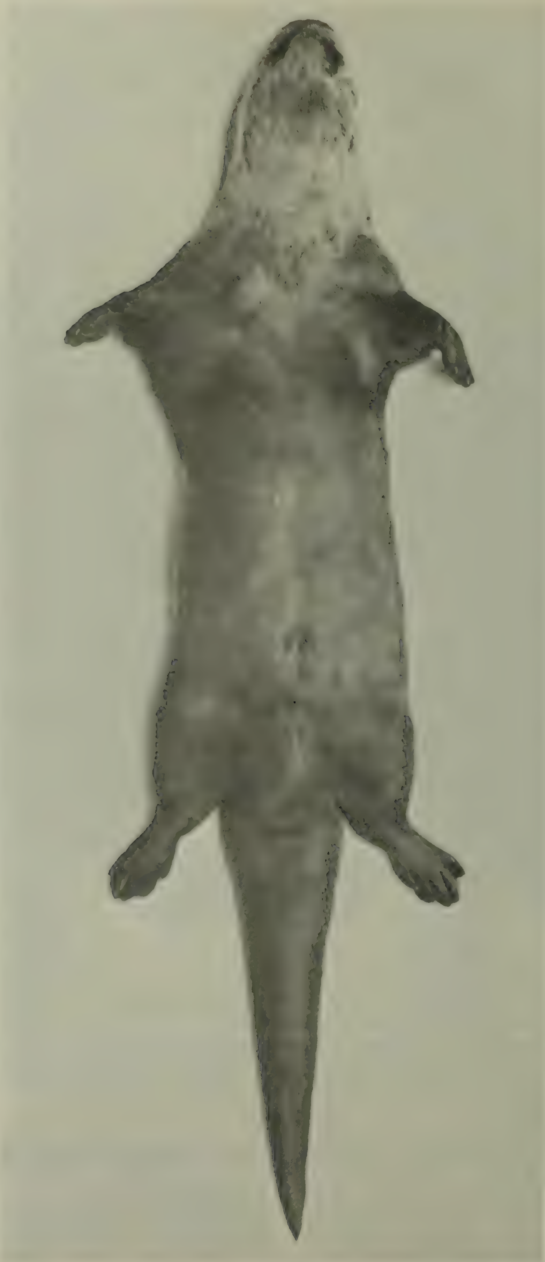


FIGURE 5.—Adult male river otter. When compared with the sea otter, th river otter's tail is long, heavy at its base, and tapered. The hind fee although webbed, are relatively small, and the body is less elongate tha that of the sea otter. (Specimen VBS 1322, length 122 cm. [48 in.], weigh 23.25 lb. [10.5 kg.], taken 8 December 1945 near Forks, Wash.) (VB 1940)

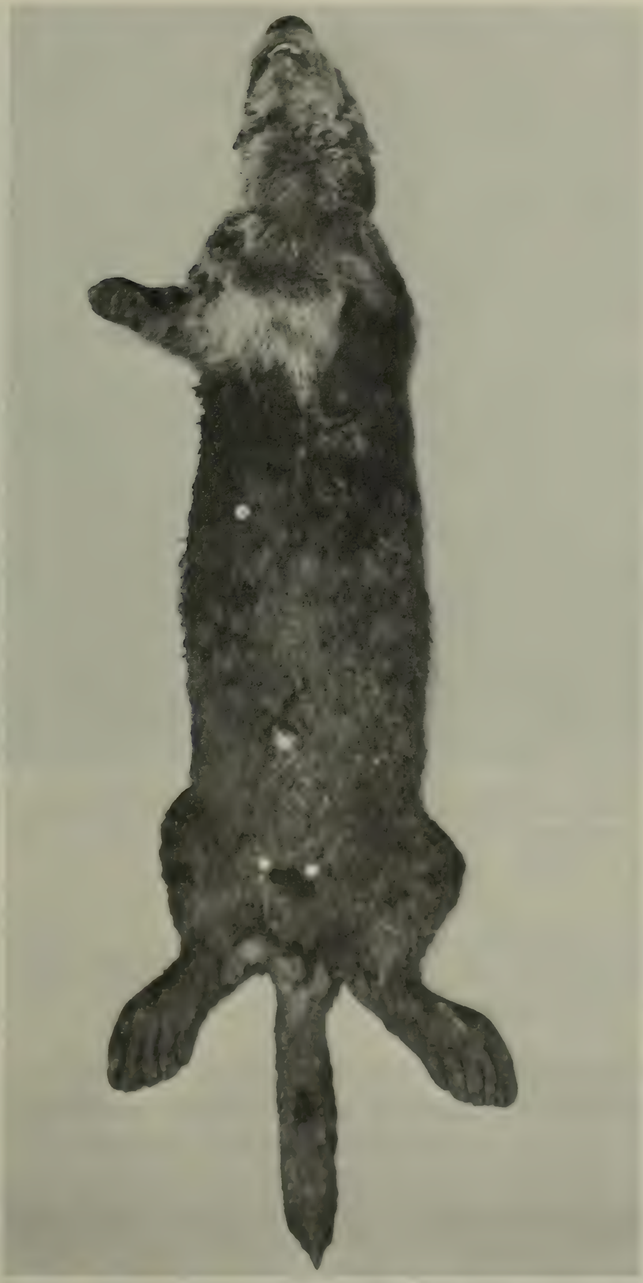


FIGURE 6.—A small adult female sea otter. White dots mark the umbilicus and mammae. The relatively short, flattened tail of nearly uniform width throughout its length, broadly flattened and webbed hind feet, and elongate body are obvious characteristics which differentiate the sea otter from the river otter. (Specimen KWK 61–2 [Susie], weight in life 40 lb. [18. 1 kg.], length 127 cm. [50 in.]. Captured 4 September 1955, Amchitka Island, died 27 October 1961 in Seattle zoo.) (KWK 61–42–16)

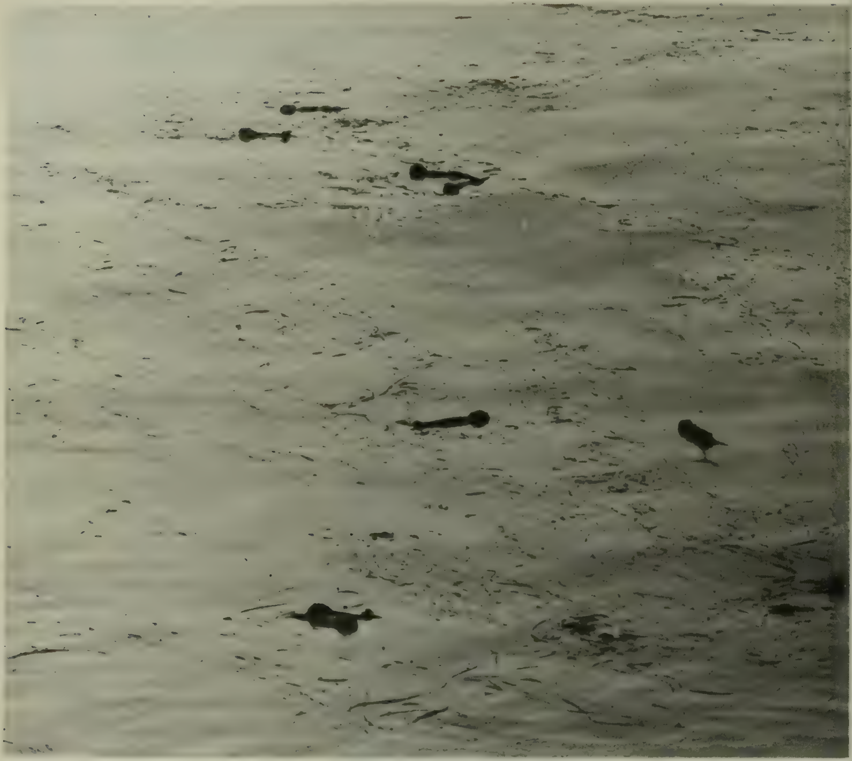


FIGURE 7.—Eight sea otters asleep in a kelp bed at Amchitka Island during a midday rest period. In the foreground a large juvenile rests its head on its mother's abdomen. (KWK 55–18–18)

7. Eyes do not open until age 25-35 days.
8. Last upper molariform tooth not broadly flattened and greatest width less than ½ inch.
9. Baculum of adult about 4 inches in length.

FIELD RECOGNITION OF THE SEXES

The sex of a living sea otter in the field may be recognized at a reasonable distance if prevailing weather conditions offer good light and visibility. The fact that the sea otter habitually rests on its back and floats high in the water facilitates recognition of the sexes. If the sea otter is wet, so that the fur is slick, the penial bulge of the male (fig. 11) and the two abdominal mammae of the female (fig. 12) may be visible with binoculars up to a distance of about 100 yards. When the fur is dry and fluffy, these definitive characters are less distinct but are visible at close range.

No instance is known of a male otter carrying a pup on its chest

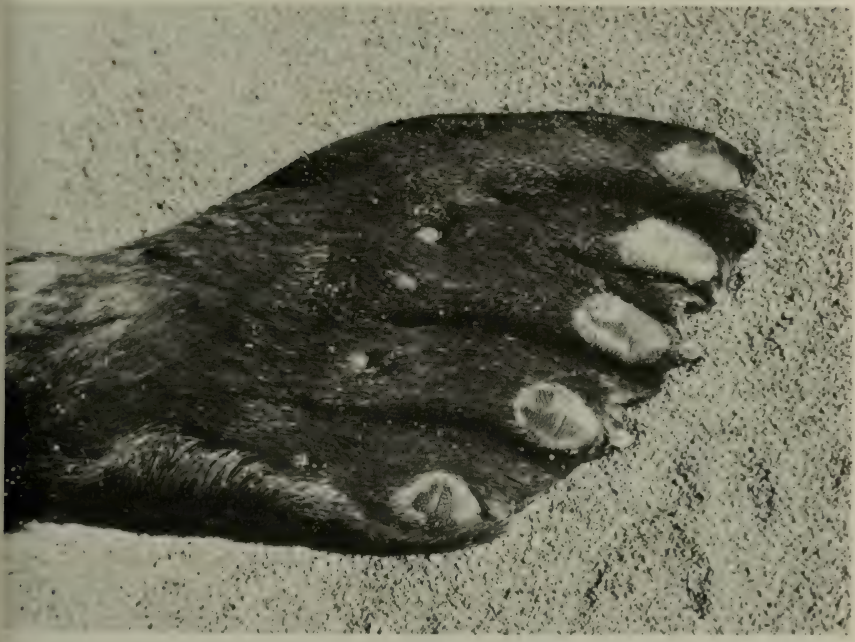


FIGURE 8.—Plantar surface of the left hind foot of an adult male sea otter. The outer (fifth) digit is longest, a condition not found in other mammals. This adaptation increases efficiency of propulsion by the foot when the otter swims on its back. Pad development at the tips of the toes is minimal. The vestigial pads near the center of the foot are not visible on some individuals. (KWK 62–23–26)

or abdomen. Thus, all animals carrying young are recognized as females. Large juveniles, still with their mothers, may approach an adult male and romp with him. Thus care is necessary during observation to differentiate between the mother and a "visiting" male.

It was shown that the adult male averages larger than the female (see Body Measurements) but because of overlap, size alone is not useful in recognition of the sexes.

The head and neck are heavier and more muscular in appearance in the adult male than in the female. If a mated pair is observed, this difference is apparent. Because of individual variation, however, much observation and field experience is necessary before this relatively slight difference becomes a useful character in the recognition of sex.

In its behavior, the male sea otter is relatively bold. If a human approaches a group of males and females hauled out near each

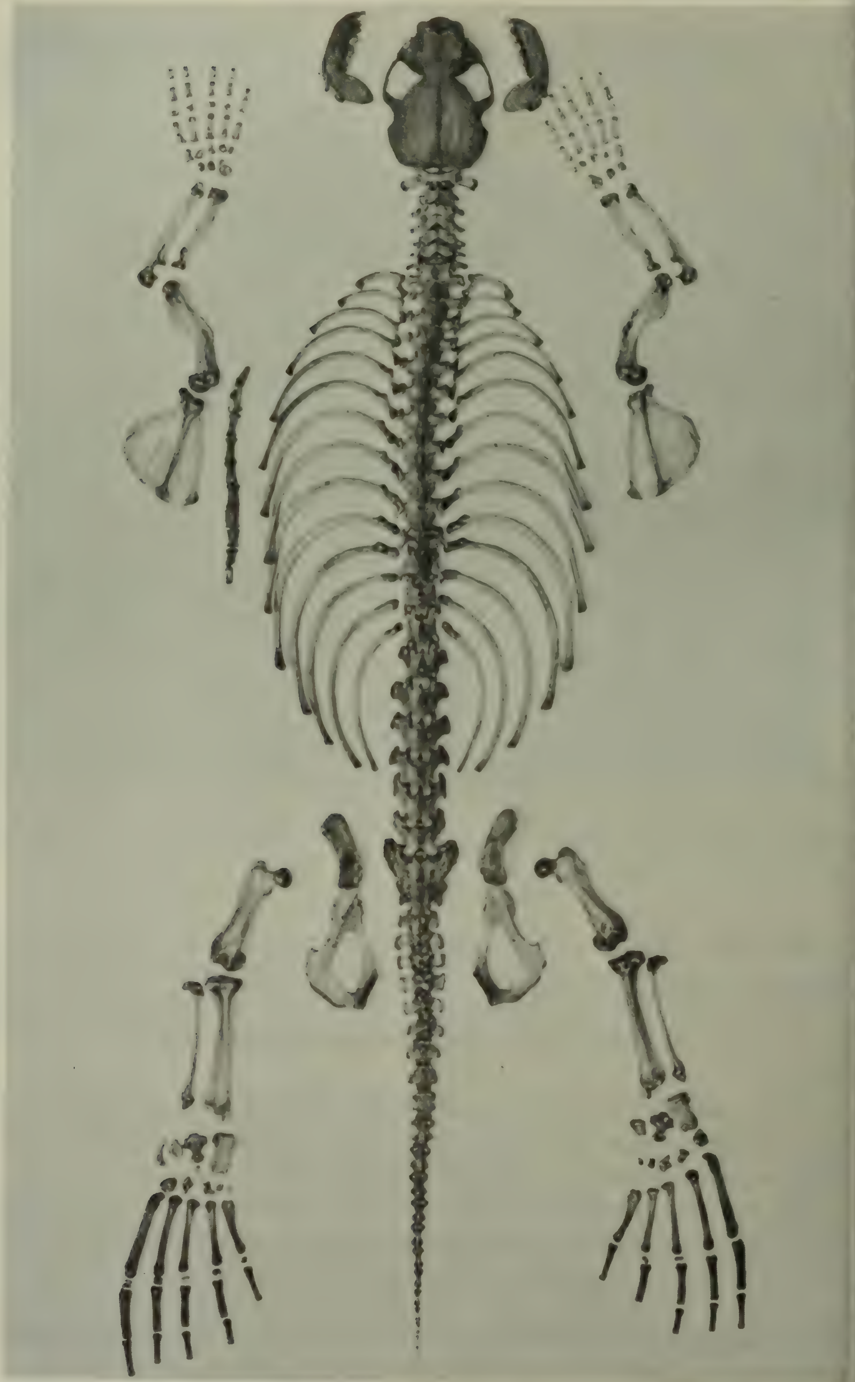
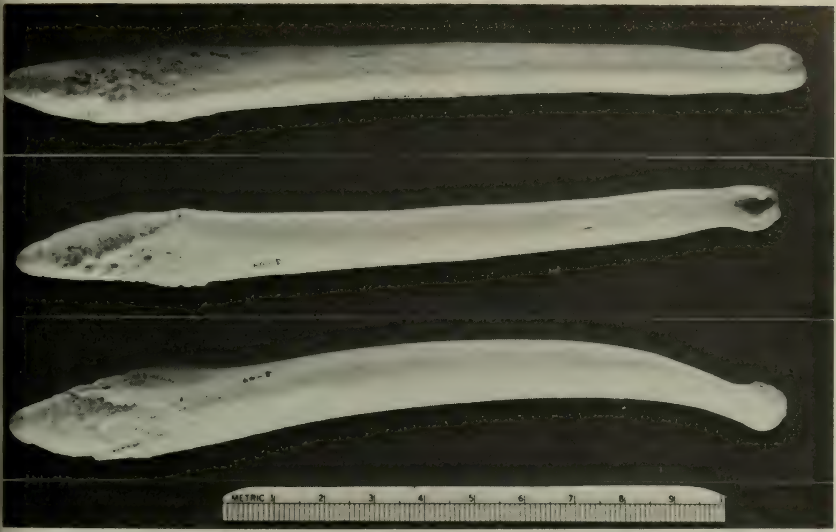


FIGURE 9.—The skeleton of an adult female sea otter (No. KWK 61–2) shows the general location and shape of the bones. The last joint of each digit was removed with the skin and is missing. The elongate fifth digit of the hind foot is demonstrated. (VBS 4954)



IGURE 10.—The baculum of an adult male sea otter (No. KWK 60–8). Above, dorsal view; middle, ventral view; below, side view. The baculum is attached to the ischium by a ligament, composed of the ischiocavernosus and bulbocavernosus muscles, which inserts on the left. (KWK 66–15)

IGURE 11.—Adult male sea otter. The penial and testicular bulges are evident when the outer pelage is wet and slick. They are less apparent when the pelage is dry and fluffy, making identification of sex difficult in the field. Note loose skin pouches beneath each foreleg. These are used to store food organisms as they are gathered from the bottom, until they are eaten at the surface. (KWK 56–29–11)

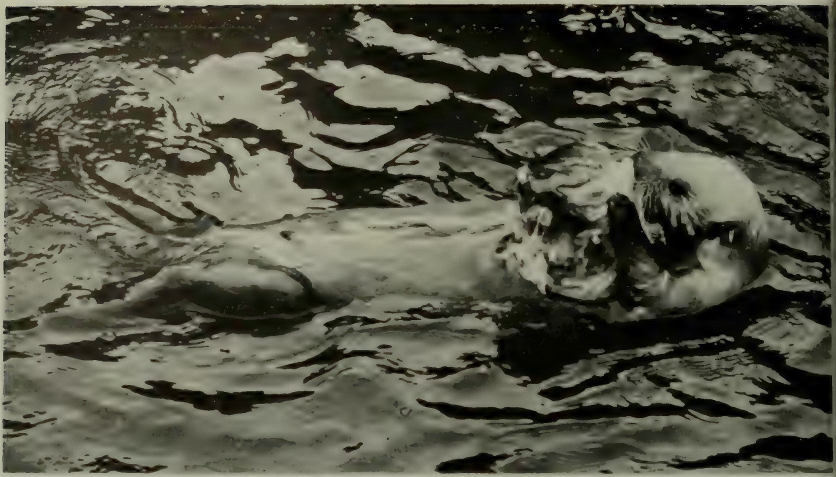


FIGURE 12.—Adult female sea otter eating the head of a large codfi (*Gadus macrocephalus*). Note the two abdominal mammae and that t head and neck are relatively of lighter structure when compared with t male. Also, females float somewhat higher in the water than do mal This is an unusually light-colored animal (albinistic), but the extremiti and eyes were normally pigmented. (KWK 59-13-2)

other, the females usually take alarm and depart before t males do.

On several occasions we pursued sea otters in an outboar powered dory in order to capture them in a dip net. Femal attempted to leave the vicinity by making long dives. The relativel fearless males often tried only to avoid the immediate vicinity the boat. One individual surfaced repeatedly in the same gener area. After about an hour of fruitless pursuit, we abandoned t chase and the otter began diving for food near the place we fir saw him.

The difference in color between adult males and females wa not quantitatively determined. In general, females appear quit black when their fur is dry and fluffy. Males, in general, appea brownish under the same conditions. Black males and brownis females, however, are seen. Both sexes tend to become whit headed with age. Dark-headed individuals, however, were exa ined which had worn teeth, indicating advanced age. Among group of 10 captive juvenile otters, the animals having the lighte colored heads were males. In general, this difference tends t prevail also in older animals.

Examination of the photographs and this discussion of diag nostic characteristics, indicate that the sex of many otters ma be recognized in the natural environment. Seldom, however, may the sex of all adult or subadult otters seen during a period of observation be positively identified.

During hunting it was demonstrated that recognition of sex in the field is impractical when obtaining skins is the primary objective. Between 31 July and 3 August 1963, officials of the Alaska Department of Game shot 20 sea otters of adult size. Mothers accompanied by pups were omitted from the kill in the hope that a high proportion of males would be obtained. Only one male (5 percent of the kill) was taken in the "female areas" where this collection was obtained.

Body Measurements

Stullken and Kirkpatrick (1955) described some of the physical characteristics of the sea otter and reported on physiological studies of captive otters. My observations are intended to supplement theirs.

Body weights and lengths of sea otters captured or found dead on Amchitka beaches, or shot in waters near Amchitka, and of otters taken in other Alaska areas are discussed in this section. Because no anatomical feature is known to reveal the exact age of a sea otter, juveniles and subadults are omitted and only data from newly born and adult animals are presented. Sea otters were recognized as adults by observations of adult dentition, suture closure and sagittal crest development of the skull, and of the baculum size in males.

Total length was obtained by measuring, with a steel tape, each animal from tip of nose to tip of tail as it lay flat on its back. Only the total length is considered in the following discussion. (The mean tail length was found to be 24.5 percent of the total length. The range in 10 adult males was 22.3 to 29.2 percent and in 10 adult females 22.0 to 26.1 percent.) Some animals killed during the Alaska State harvesting operations could not be measured immediately after death. When an animal in rigor mortis was measured, an attempt was made to stretch it to full length. Some of these, however, were probably measured as being slightly shorter than they would have been when relaxed.

The scales most frequently available were spring scales of 50- and 100-lb. capacity. The data as shown in tables were converted to kilograms. Small young were usually weighed on a 15-kg. capacity balance.

NEWBORN YOUNG

The data on body size of the youngest sea otters obtained are reported in table 1. The umbilical scar was fresh on each individual listed and all showed little or no wear of the fetal claw tips (fig. 13). The two smallest, a male weighing 2.6 lb. (1.2 kg.) and a female weighing 2.25 lb. (1.02 kg.), were both dead when obtained, one from the beach and the other from a mother that was netted on the beach while carrying her dead pup. Among the seven largest fetuses (four males and three females), collected at Amchitka in 1963, the largest, a male, weighed 4.12 lb. (1.869 kg.) and measured 61.0 cm. in length. The mean weight was 3.5 lb. (1.598 kg.) and the mean length 57.3 cm. (22.5 in.). Thus it is probable that the two smallest newborn young were stillborn, being abnormally small at birth. All of the others had received at least some nourishment in the form of milk from their mothers before capture, thus were heavier than when newly born. The living young examined indicate that a healthy newly born sea otter may weigh as little as 3 lb. (1.4 kg.). But the fetal material studied (see Reproduction in the Female) and larger newborn young indicate that larger body size of 4.12 lb. (1.869 kg.) to 5 lb. (2.3 kg.) and 61 cm. (24 in.) in total body length is probably normal.

ADULTS

Analysis of the weights and lengths of 84 adult males and 258 adult females that were shot, are given in tables 2 and 3. Animals

TABLE 1.—*Weight and length of newborn pups taken at Amchitka Island, Alaska*

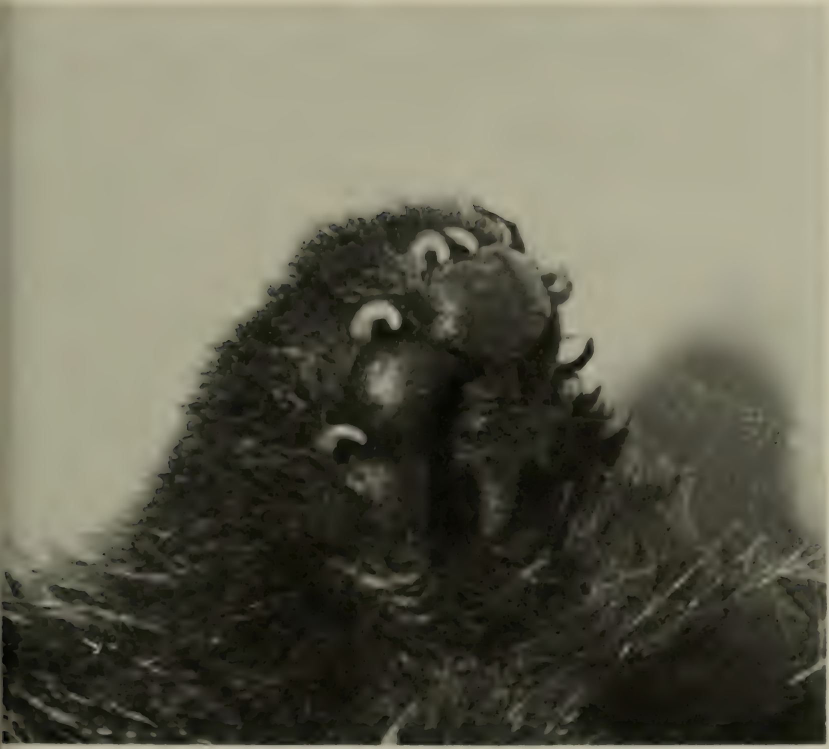
[The umbilical scar or adhering fragments of the umbilical cord were fresh. All except the two dead pups contained small quantities of milk]

Collection number	Date	Weight	Length
		Kg.	*Cm.*
Males:			
	29 March 1955	1.6	58.0
32–56 [1]	26 May 1956	1.2	47.3
D–6–57	18 November 1957	2.5	62.9
62–178	18 February 1962	1.7	52.8
Mean		1.75	55.25
Females:			
32–56 [2]	25 May 1956	1.02	48.4
D–2–57	11 October 1957	1.45	52.1
D–15–57	16 October 1957	2.4	——
(3)	15 Apr. 1959	1.7	——
60–17	8 July 1960	2.35	53.5
60–21	10 July 1960	2.83	61.6
Mean		1.96	53.9

[1] Freshly dead pup taken from the mother when she was netted.

[2] Freshly dead pup found on beach.

[3] Mother and pup netted and released. The pup was not tagged because it was obviously newborn (umbilicus still attached and fresh).



GURE 13—At birth the claws are white and curved. Soon after birth the young otter attempts to groom its fur, and the soft tips are lost. (KWK 62–16–21)

und dead on beaches (table 4) and those which died in captivity ables 5 and 6) are compared and the differences are discussed low.

Scheffer (1951) published information on the body size of three ult sea otter specimens which he measured. The present data nfirm that the maximum length of the adult male sea otter is out 148 cm. (58.25 in.), that the adult female is 140 cm. (55 in.). e adult male may reach a maximum weight of about 100 lb. (45 .) and the adult female may reach a weight of at least 72 lb. 2.6 kg.).

It is indicated in other sections (see Food and Feeding Behavior, ortality Factors, and Distribution and Numbers) that at Amitka Island a dense sea otter population has depleted food sources. Additional evidence for this is revealed by comparing e body weights of Amchitka sea otters (table 2) with animals om a sparse population (table 3).

TABLE 2.—*Total length and body weight of adult sea otters killed at Amchitka Island, Alaska*

Item	Male					Female				
	1959 [1]	1962 [2]	1962 [3]	1963 [4]	All	1959 [1]	1962 [2]	1962 [3]	1963 [4]	All
Number	13	24	3	39	79	8	99	16	131	254
Maximum weight ......kg.	38.6	36.3	32.6	38.6	38.6	28.1	26.8	26.8	31.7	31.7
Minimum weight ......kg.	22.7	22.7	26.3	21.8	21.8	15.4	14.5	15.9	15.4	14.5
Mean weight ......kg.	28.7	28.2	28.7	28.1	28.3	20.7	20.4	21.9	21.5	21.1
Standard deviation	7.84	7.45	7.58	6.24	7.93	4.13	5.81	5.15	6.81	6.49
Maximum length ......cm.	145	140	145	142	145	135	136	133	140	140
Minimum length ......cm.	132	126	132	137	126	124	112	109	107	107
Mean length ......cm.	139.7	134.5	137.7	133.6	135.0	129.4	125.3	124.7	124.9	125.2
Standard deviation	4.13	3.53	6.67	3.53	4.30	3.29	4.65	5.77	4.64	4.73

[1] Animals netted on beaches, February-May.

[2] Animals shot, January-March.

[3] Animals shot, October.

[4] Animals shot, March-April. Thirty-four males shown to be subadult by baculum measurements are omitted. Their mean weight was 47.9 lb. (21.7 kg.) and mean length was 123.9 cm. (48.7 in.).

BLE 3.—*Total length and body weight of adult sea otters killed in areas of sparse population*

hese otters were shot in 1960 in the Shumagin Islands (6), off Unimak Island (2), and Adak Island (1)]

Item	Males	Females
mber	5	4
ximum weight ....kilograms	44.9	32.7
nimum weight ....do	34.0	19.9
an weight ....do	39.5	25.2
ndard deviation	10.12	13.0
ximum length ....centimeters	143	139
nimum length ....do	140	125
an length ....do	140.8	129.8
ndard deviation	0.5	6.3

BLE 4.—*Total length and body weight of adult sea otters found dead on beaches at Amchitka Island, Alaska*

eights and measurements could be obtained from relatively few of the total found. All are combined in this table: 1956 (1), 1959 (7), 1962 (20), and 1963 (2)]

Item	Males	Females
mber	13	17
ximum weight ....kilograms	31.7	18.6
nimum weight ....do	15.9	12.2
an weight ....do	21.4	16.2
ndard deviation	10.20	3.83
ximum length ....centimeters	145	137
nimum length ....do	130	122
an length ....do	136.5	131.7
ndard deviation	4.39	3.74

TABLE 5.—*Weight loss of 10 adult male sea otters that died in captivity*

[Weight in kilograms]

Collection number	Weight at capture	Weight at death	Weight loss	Percent loss	Days in captivity
56	33.6	25.4	8.2	24	15
-56	32.7	22.5	10.2	31	18
-56	33.6	24.0	9.6	28	15
I-56	26.3	19.5	6.8	26	8
-56	25.8	18.1	7.7	30	47
3-57	20.4	17.9	2.5	12	7
20-57	30.4	26.3	4.1	13	20
21-57	29.5	26.8	2.7	9	13
22-57	31.7	20.9	10.8	31	17
15-57	28.6	20.9	7.7	27	305
Mean	29.25	22.23	7.03	24	—

BLE 6.—*Weight loss of seven adult female sea otters that died in captivity*

[Weight in kilograms]

Collection number	Weight at capture	Weight at death	Weight loss	Percent loss	Days in captivity
6	21.3	19.3	2.0	9	6
-56	23.1	15.0	8.1	35	57
-56	24.0	17.0	7.0	29	15
-57	25.4	21.3	4.1	16	6
16-57	27.2	23.4	3.8	14	27
17-57	22.2	19.7	2.5	11	25
8-57	22.5	18.5	2.3	10	10
Mean	23.67	19.17	4.50	19	—

Scheffer (1955) concluded that a reduction in body size wa correlated with increasing population or crowding in the norther fur seal *(Callorhinus ursinus)*. The data presented below indicat that adult sea otters from a crowded population weigh less tha animals from a sparse population. The length of adult otters fror sparse populations fell within the length range of otters from th crowded Amchitka population (tables 2 and 3). However, a insufficient number of animals from sparse populations wer available to demonstrate a statistically significant difference at th conventional level of 0.05.

Although few adult sea otter specimens (five males and fou females) are available from areas where sea otter populations ar sparse, the differences in body weight between these animals an the Amchitka collection are noteworthy. Among 79 adult male that were killed at Amchitka, the mean weight was 62.5 lb. (28. kg.), and the heaviest weighed 85 lb. (38.6 kg.). Among five tha were killed in sparsely populated areas, however, the mean weigh was 87.1 lb. (39.5 kg.) and the heaviest weighed 99 lb. (44.9 kg.) The difference between the mean weights of these two samples i 24.6 lb. (11.2 kg.). This indicates that adult males in a spars population may average about 28 percent heavier than those i crowded populations. The difference is significant at the 0.1 pe cent level. The mean weight of four females from sparsely popu lated areas was about 16 percent greater than the mean weigh of 254 Amchitka females. When the animals were collected i sparsely populated areas, no effort was made to select larg individuals.

The lesser body weights of the Amchitka animals appear t confirm conclusions drawn from food habits and mortality studie that a large population there has created ecological condition which are below the optimum. Because the sample of adult otter from sparsely populated areas is small, a more thorough statistic evaluation of the apparent differences in mean body weight b tween crowded and sparse populations must be delayed until mor data are gathered.

Most of the sea otters killed at Amchitka were taken durin the late winter to early spring period of environmental stress whe many of the otters were dying. Thus, it appears appropriate t compare the animals killed at this season with others taken a Amchitka in the fall when body condition would be expected t be optimum. Unfortunately, the only fall (1962) sample of adult is small, consisting of 3 males and 16 females. Comparison of th mean weights of these animals with those taken in the late winte to early spring period indicates no statistically significant difference in body condition (table 2). The sea otter must maintain a high daily intake of food regardless of season. It is reasonable to suppose that those animals capable of maintaining themselves under the feeding conditions imposed by a maximum otter population would show little seasonal differences in body weight.

WEIGHT LOSS PRECEDING DEATH

Death, in the wild and in captivity, is usually preceded by a period of physical deterioration evidenced by gradual or precipitous loss of body weight. The mean weight of 13 adult males found dead on Amchitka beaches was 47.1 lb. (21.4 kg.) (table 4). The mean weight of 79 adult males that were shot near the same places was 62.5 lb. (28.3 kg.) (table 2). The mean weight difference was 15.2 lb. (6.9 kg.), indicating that preceding death the moribund animals lost 24 percent or about one-quarter of their body weight. Similarly, between 254 adult females that were shot and 17 that were found dead on beaches the mean weight difference was 10.8 lb. (4.9 kg.) (21.1 kg. minus 16.2 kg., tables 2 and 4), or an indicated reduction of about 23 percent.

Seventeen adult sea otters (10 males and 7 females) were weighed at capture and again after they died in captivity. These animals were held captive for periods varying from 6 days to 10 months (tables 5 and 6). Among 10 adult males that died in captivity, the mean weight loss at death was 24 percent of the body weight at capture. Three animals in this group lost 30 percent or more of their body weight (table 5). Data for adult females are similar (table 6).

Massive weight loss preceding death appears to result from (1) evacuation of the gastrointestinal tract, (2) consumption of body fat reserves, and (3) dehydration. The usual terminal symptoms, in wild and captive animals, was excretion of black, tarry feces due to enteritis.

After an adult otter enters a period of physical decline, the restoration of normal vigor and weight may be difficult or impossible by any known means. The afflicted animal may become increasingly lethargic and may consume little or no food. Some emaciated juveniles captured on beaches, however, recovered when given adequate food in captivity.

In summary, there is evidence that among adult otters of about the same body length, those from areas of sparse population may weigh about 16 to 28 percent more than apparently healthy animals from a densely populated area and about 50 percent more than emaciated individuals which die on beaches in a densely populated area. Animals in captivity, taken in a densely populated area (Amchitka), lost about 25 percent of their body weight at capture, before death.

MISCELLANEOUS MEASUREMENTS

Skin length and body length

The skin of the sea otter is "loose" and stretches considerably after it is removed from the animal, as shown by the following figures:

Specimen	Sex	Body length[1]		Skin length[2]		Percent increase	Remarks
		Millimeters	Inches	Millimeters	Inches		
KWK 59-61	♀	720	28¾	1,035	40¾	44	Fresh skin.
KWK 59-77	♀	1,320	51¼	1,850	72¾	42	Fresh skin.
BDM 128	♂	1,478	58	1,715	67½	16	Tanned skin.

[1] Tip of nose to tip of tail flesh.
[2] Moderate tension applied.

Thus, a skin freshly removed from the animal may easily be stretched 144 percent and a tanned skin 116 percent of the animal's body length. It is concluded that measurements taken from skins are of little use in establishing body size in the sea otter.

Intestine length

Length of intestine in four adult sea otters is shown in table 7. Shortly after death, the intestinal tract was removed, laid on flat ground, and measured. An effort was made to obtain the relaxed length (not the stretched length). The mean length of the small intestine was 9.0 times body length (table 7).

In general, carnivores have shorter intestines than herbivores but the variation among strictly carnivorous mammals is great.

TABLE 7.—*Intestine length of adult sea otters*

[Length in centimeters]

Collection number	Sex	Body length	Intestine length[1]	Small intestine[2]	Ratio, small intestine to body length
59-60	female	124.	1,214 (39.5 feet)	1,154	9.3:1
61-2	do	127.	1,076 (35.3 feet)	1,016	8.0:1
62-11	do	128.	1,313 (43.1 feet)	1,253	9.8:1
62-10	male	136.	1,290 (42.3 feet)	1,230	9.0:1
Mean		128.7			9.0:1

[1] From stomach to anus.

[2] No caecum is present in the sea otter. The small intestine gradually expands into the large intestine. The approximate length of the large intestine is 60 cm. This amount is subtracted from the total intestine length to obtain the approximate length of the small intestine.

mong pinnipeds, which subsist entirely on flesh, the ratio $\frac{\text{mall intestine length)}}{\text{nose-tail length}}$ ranges from 5.2 in *Monachus* to 42.0 in *'irounga* (King, 1964). The sea otter, which subsists on marine .vertebrates and fish, falls within this general range. Apparently ıimals which feed primarily on warm-blooded vertebrates have ·latively shorter intestines. The above ratio is 5 for the dog and ıt (King, 1964).

rgan weights

The relative sizes of body organs may give a clue to the adap- tions of an organism to its environment. I have undertaken no ıysiological studies, but the following comparisons of the relative ze of selected body organs of the sea otter with those of other ammals indicate that such studies would be interesting and ·sirable.

Organs were weighed on a balance having a maximum capacity 15 kg. Sample organ weights were obtained from six adult ale and nine adult female sea otters that were shot while ap- ırently in normal health at Amchitka Island and other areas able 8). Comparison of the organ weight expressed as percent body weight indicates that in some respects the sea otter is quite

.BLE 8.—*Weights of body organs in nine adult female and six adult male sea otters*

'eight in grams. All apparently healthy adults shot at Amchitka Island, except 60–4 to 60–8 which were shot in the Shumagin Islands and off Unimak Island]

Collection number	Body weight	Liver		Heart		Kidney		Spleen	
		Weight	Percent of body weight	Weight	Percent of body weight	Weight	Percent of body weight	Weight	Percent of body weight
nales:									
62–2	21,770	1,219	5.60	182	0.84	409	1.88	65	0.30
62–6	20,410	1,130	5.54	152	.74	340	1.67	59	.29
62–8	19,950	1,135	5.69	130	.65	367	1.84	65	.33
62–11	20,410	1,730	8.48	126	.62	346	1.69	90	.44
62–12	23,130	1,632	7.06	160	.69	425	1.84	90	.39
62–15	21,300	1,226	5.76	135	.63	385	1.81	92	.43
62–19	19,050	955	5.01	134	.70	315	1.65	85	.45
62–20	17,690	1,000	5.65	142	.80	350	1.98	58	.33
60–4	32,500	1,450	4.46	175	.54	470	1.45	150	.46
Mean	21,800	1,275.2	5.85	148.4	.68	378.5	1.74	83.8	.38
es:									
62–1	29,940	1,479	4.94	185	.62	700	2.34	86	.29
62–10	36,290	2,685	7.39	211	.58	821	2.26	177	.49
60–5	35,500	1,650	4.65	230	.65	870	2.45	100	.28
60–6	45,000	2,390	5.31	270	.60	1,120	2.49	110	.24
60–7	41,300	1,860	4.50	272	.66	997	2.41	113	.27
60–8	41,700	2,086	5.00	227	.54	1,026	2.46	113	.27
Mean	38,280	2,025	5.29	233	.61	922	2.40	116	.31
Mean, all	28,410	1,575	5.67	182.1	.66	596.1	2.01	96.9	.35

similar to other mammals but in other respects it may be uniqu Among mammals in general (but with exceptions) total boc weight increases at a greater rate than organ weights. It is pr sumed in the following comparisons that the reader will keep th generalization in mind.

Liver.—To remain healthy the sea otter must consume abo one-sixth to one-fourth of its body weight in food daily. A parently the air blanket in its fur is a less efficient means insulation in its chilly habitat than the blubber of other mari mammals. The need for a relatively large amount of food i dicates an unusually high metabolic rate in the sea otter. Slijp (1962) believes that marine mammals, and particularly cetacean have a high metabolic rate. Since the liver is an important org for the production and storage of energy-producing substance it is not surprising that the sea otter's liver is relatively ve large; the mean is about 5.7 percent of body weight. In this respe it surpasses fur seals of comparable body size (mean 3.1 to 3 percent; Scheffer, 1960), porpoises (3.2 percent), and dolphi (2.2 percent; Slijper, 1962), and the river otter (4.85 percen Jensen, letter, 30 Nov. 1964), although the river otter is a small animal.

Heart.—The heart of the sea otter constitutes about 0. percent of body weight. The ratio is similar to that of fur sea of comparable size (about 0.6 percent of body weight; Scheffe 1960), and to dolphins (0.6 percent; Slijper, 1962). As Jens (1964) points out, sea water gives more support than fresh wat and therefore the sea otter may not need as large a heart as t river otter (0.98 percent of body weight).

Kidney.—The marine environment may account for a lar difference in relative size between the sea otter kidney, mean 2. percent of body weight, and that of the river otter, 0.85 perce of body weight. The sea otter appears to have overcome the phy ological problem of the marine environment by developing lobulate kidney relatively twice as large as that of the riv otter. I have observed sea otters in captivity drinking sea wate A study of the physiology involved has not been undertaken. Th the sea otter obtains liquids of appreciably less salinity than s water from food is improbable, since body fluids of invertebrat

---

[2] The captives were held for 2 months on dry bedding at Amchitka. Frequently when I h a pan of sea water before them they placed their mouths in the water and sucked and lap it up with their tongues. In their eagerness to drink, they also placed their forepaws in dish and eventually spilled and splashed so much of the water that I did not measure the qu tity that was actually drunk. When given a choice of sea or fresh water they drank eit unselectively. Except for one experimental offering of fresh water the captives were given o sea water.

upon which some otters feed almost exclusively, are isotonic, or nearly so, with sea water (Sverdrup, Johnson, and Flemming, 1942, p. 269).

Fisler (1962) demonstrated that even a mouse *(Peromyscus* sp.), that was adapted before capture to a salt marsh environment, survived when given sea water exclusively.

Slijper (1962, p. 314) considers that the kidneys of cetaceans (from 0.44 percent to 1.1 percent of body weight) are, because of great body size, exceptionally large. In general, a large kidney appears to constitute an important aspect of mammalian adaptation to the marine environment.

Spleen.—In the sea otter the spleen is about 0.35 percent of total body weight, which is similar to "0.3 percent in most other mammals" (Slijper, 1962, p. 175). In 62 female fur seals similar in size to the sea otters studied, Scheffer (1960) found that the spleen was from 0.11 to 0.31 percent of body weight. Thus, in the sea otter and river otter (0.46 percent, Jensen, 1964) the spleen is relatively large.

Although the mean percentages of organ size to body weight of all sea otters studied were used in the foregoing general discussion, it appears that in the male, which is larger than the female (see Body Measurements) the kidney is relatively larger than in the female. Also, the spleen of the female is slightly larger than in the male (table 8).

Body temperature

The body temperature of two apparently healthy animals, a juvenile male (59–156) and an adult female (59–157), were obtained when both had lost consciousness after injections of "Lethol" (proprietary name for a compound containing N-amylethyl-barbituate, sodium sec-butylethyl-barbituate, isopropyl alcohol, and sodium carbonate). The deep body temperatures (intracardiac insertion of the thermometer before cardiac activity ceased) and rectal temperatures were the same. The temperature of the juvenile male was 38.0° C. (100° F.) and that of the adult female was 37.5° C. (99° F.).

Body temperature may drop before death under certain conditions. On 1 April 1959, at Amchitka Island, an emaciated adult female (59–98) was lying on a bed of grass above the high tide line, breathing but unconscious. Her intracardiac temperature was 28.0° C. (84° F.). An autopsy revealed extensive enteritis.

During an experimental transplant, observations were made of a juvenile subjected to unusual stress. The otter, a female about

1 year old and weighing 22 pounds, was liberated in cold water (0° C.) on 9 April 1955. The fur had become saturated with filth after 8 days in captivity. Within 1 minute after entering the water the otter uttered loud distress screams and swam toward our dory. After she was retrieved she was placed on dry straw. When we returned to the ship, about 20 minutes later, the otter was unconscious. The rectal temperature was 30.3° C. (86° F.). In a warm room, the fur was vigorously rubbed and dried with a towel and consciousness was restored. At 0700 the following morning the rectal temperature was 38.5° C. (99° F.) ; the animal appeared weak but ate. She was kept in a warm room (about 22° to 24° C. or 72° to 75° F.) and given almost constant attention until she died on 15 April. During this period her body temperature fluctuated erratically each day from 30° to 36° C. (86° to 96° F.). When her temperature was low, I recorded that she was "almost in a coma." Apparently after chilling, the temperature control mechanism of this otter was upset.

Blood quantity

An approximation of the blood content of sea otters was obtained from five freshly killed animals (table 9). All appeared to be in normal health when killed. The technique used in each case was the same: After capture the animal was given a lethal injection of Lethol. When the animal lost consciousness, it was weighed and measured. The thoracic cavity and heart were opened. The animal was suspended, by means of lines attached to each leg, over a container into which the blood drained. In all cases the heart was still beating when the incisions were made. The blood weight and volume were measured directly.

The percentage of blood weight to body weight of four of the

TABLE 9.—*Blood quantity in sea otters*

[The weight of blood is minimal. The blood was drained from animal directly into a container. No correction was added for the slight amount that was spilled, or for the blood remaining in tissues]

Collection number	Age	Sex	Blood weight	Body weight	Percent, blood weight of body weight
			Grams	*Grams*	
59–62	Adult	male	2,694	31,297	8.6
59–156	Juvenile	do	767	11,566	6.6
59–48	Adult	female	8,106	28,122	[1] 28.8
59–60	do	do	2,100	20,978	10.0
59–157	do	do	1,531	20,865	7.34

[1] Apparently this animal was abnormal. Pathological conditions such as hydrothorax and heart failure occur in other mammals. The large quantities of fluids that accompany these conditions may be difficult to distinguish from blood.

animals (mean 8.1 percent) fall within the expected range (rabbit, 6.2 percent; dog, 7.2 percent; and horse, 9.7 percent (Dukes, 1943); and walrus, 8.4 percent (Fay, 1958)). In the fifth animal, the blood constituted nearly one-third of the body weight. This animal, when captured, was sleeping on the beach and behaved in a normal energetic way. I noted, however, that it appeared "fat" and the abdomen was round and firm. I suspected then that it was pregnant, but found later that it was not.

There was no food in the gastrointestinal tract. In addition to the blood quantity, the only abnormality found were two cysts (congenital? 1.5x1 cm. and 1.5x1.5 cm.) containing clear, yellowish fluid, on one kidney. The gross appearance of blood was normal. Why this animal retained such a large amount of fluid is unknown. There was no mistake about the quantity of fluid (table 9).

Pelage and Skin

Preliminary descriptive studies of the pelage, skin, and molt have been made.

PELAGE

Victor B. Scheffer (Marine Mammal Biological Laboratory, U.S. Fish and Wildlife Service) has made a cursory examination of pelage samples from three sea otters and has kindly offered the following notes (in letter, 13 August 1964). Unless otherwise stated, the notes are based on a sample from the midback of "Pappy," an adult male, specimen D22–57, which died in Seattle Zoo on 16 December and was autopsied on 17 December 1957.

> The pelage is an extremely fine wool or fur with the tips of thinly scattered guard hairs protruding from it. It is light smoky gray near the skin, darkening gradually to smoky brown at the surface of the pile. The *larger guard hairs* are dark; their tips make a layer about 34 mm. (1.5 in.) from the skin. The *smaller guard hairs* are more numerous than the larger ones; their tips make a layer about 28 mm. (1.25 in.) from the skin. The *underfur hairs* are by far the most numerous; their tips make a layer about 23 mm. (1 in.) from the skin. The outer surface of the underfur layer is not distinct; the soft, wavy tips of the fur hairs blend with the tips of the smaller guard hairs (fig. 14).
>
> The *pelage unit* consists of: a bundle of many underfur hairs and one guard hair at or near the anterior side of the bundle (fig. 15); a sebaceous gland on right and left sides of the bundle, joined at the anterior side; a coiled sweat gland beneath and partly adjacent to the follicles of the bundle; and other minor structures. There is apparently no hair-erecting muscle.
>
> The guard hairs vary widely in diameter and length, though they fall into

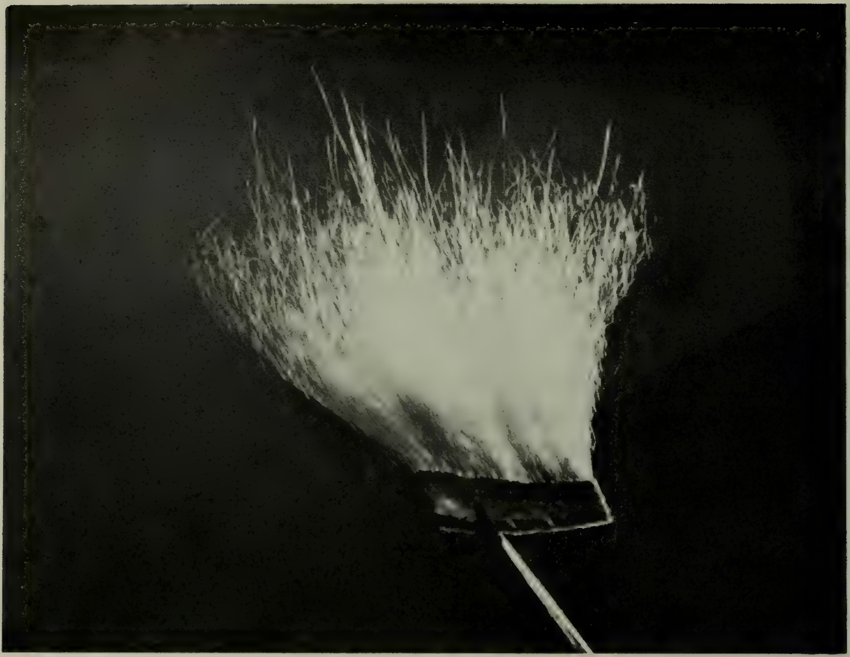


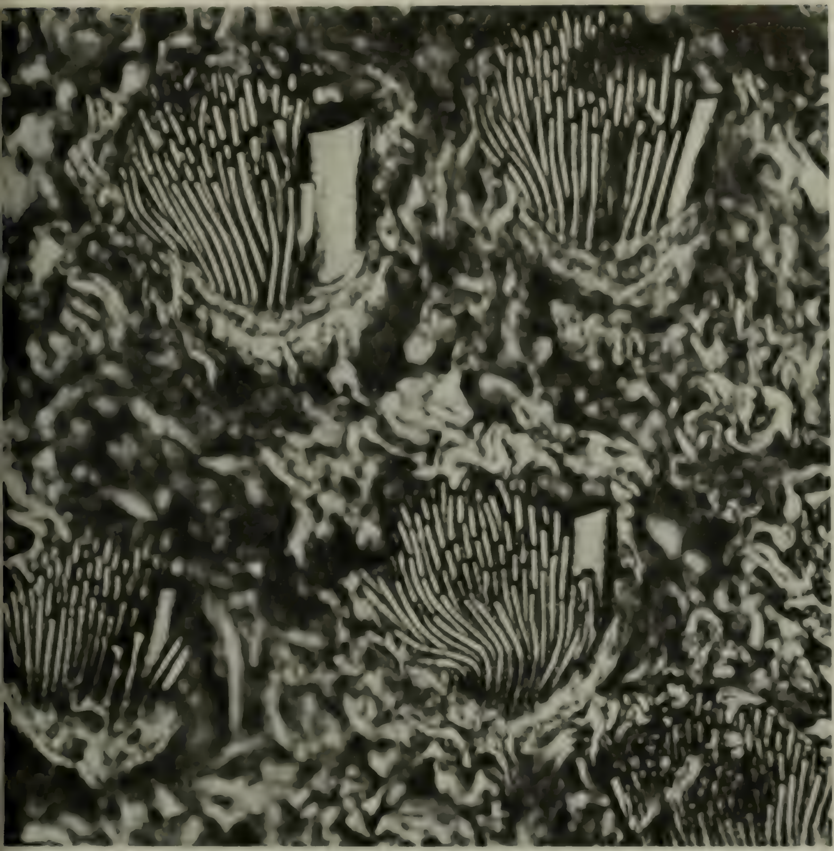
FIGURE 14.—Hair from the midback of adult male sea otter D22–57. The outer surface of the underfur layer is not distinct; the soft, wavy tips of the fur hairs blend with the tips of the smaller guard hairs. (VBS 5710)

two overlapping groups which I call "larger" and "smaller," with few intermediates. For example, here are the diameters of 10 roots in one field of view under the microscope: 14, 15, 16, 18, 20, 25, 26, 33, 38, and 64 microns (cf. fig. 16). Cross sections of the guard hair roots are oval to nearly round in outline; they vary in diameter from 13 to 64 microns (average 25).

In five bundles I count 60 to 80 (average 71) underfur roots per bundle. The counts in two other specimens are: (KWK 59–13, old female, 9 February 1959) 79–110 (average 91); (KWK 59–51, young male, 7 March 1959) 40–45 (average 43). Comprehensive studies of pelage samples from different seasons and different age groups of otters will be necessary before the extent of holdover of pelage hairs can be evaluated. Cross sections of the underfur roots are roundish oval, smooth, fairly uniform, and 6.3 to 8.5 microns (average 7.2) in diameter (fig. 16.)

A disc of skin-with-pelage cut by trephine from the formalin-preserved, mid-back specimen measured 0.4 cm^2. It contained 520 bundles or 1,400 per cm^2 (fig. 17). [That there is considerable variability is demonstrated by the finding by J. K. Ling (MS) of 2,176 follicle bundles per cm^2 on a sample of facial skin.] On the basis of 71 underfur hairs and 1 guard hair per bundle, (hairs per $cm^2 = 72 \times 1400 = 100{,}800$ or 650,160 per $in.^2$) and an estimated area of 8,000 cm^2 for the total hair-covered surface of the body, the pelage of an adult male sea otter would contain about 800 million hairs.

Above the surface of the skin, the shaft of each larger guard hair is a typical awn or shield hair, flattened into a blade near the tip. At a level 10



IGURE 15.—Plastic impression of pelage sheared near skin surface from midback of adult male sea otter D22–57. Anterior at right. Variation in the diameter of guard hairs is demonstrated and their characteristic scale-pattern. Magnification ca. × 75. (VBS 5718)

m. from the skin, the cross section is oval, slightly wavy in outline, and 55
67 microns (average 63) in diameter. The shaft of each smaller guard hair
s a small blade. The cross section of the smaller guard hair at the 10 mm.
el is 23 to 56 microns (average 42) in diameter. All guard hairs are
edullated. Near the surface of the skin, the guard hair root is often dis-
aced from the anterior side of the bundle by pressure of the underfur roots.
The cross section of the underfur hair at the 10 mm. level is irregularly 3-
4-sided (fig. 18). In this respect it resembles the underfur of the land otter
utra) (Wildman, 1954, fig. 98b). The underfur shaft is about 7 to 8 microns
cross section diameter, only slightly greater than the root.

In general, the pelage of the sea otter is similar to that of the land otter.
e guard hairs seem to be scarcer and more variable in size than those of the
d otter, though I have not made a quantitative comparison. The remark-
le arrangement of hairs in bundles, outside of which there are no isolated

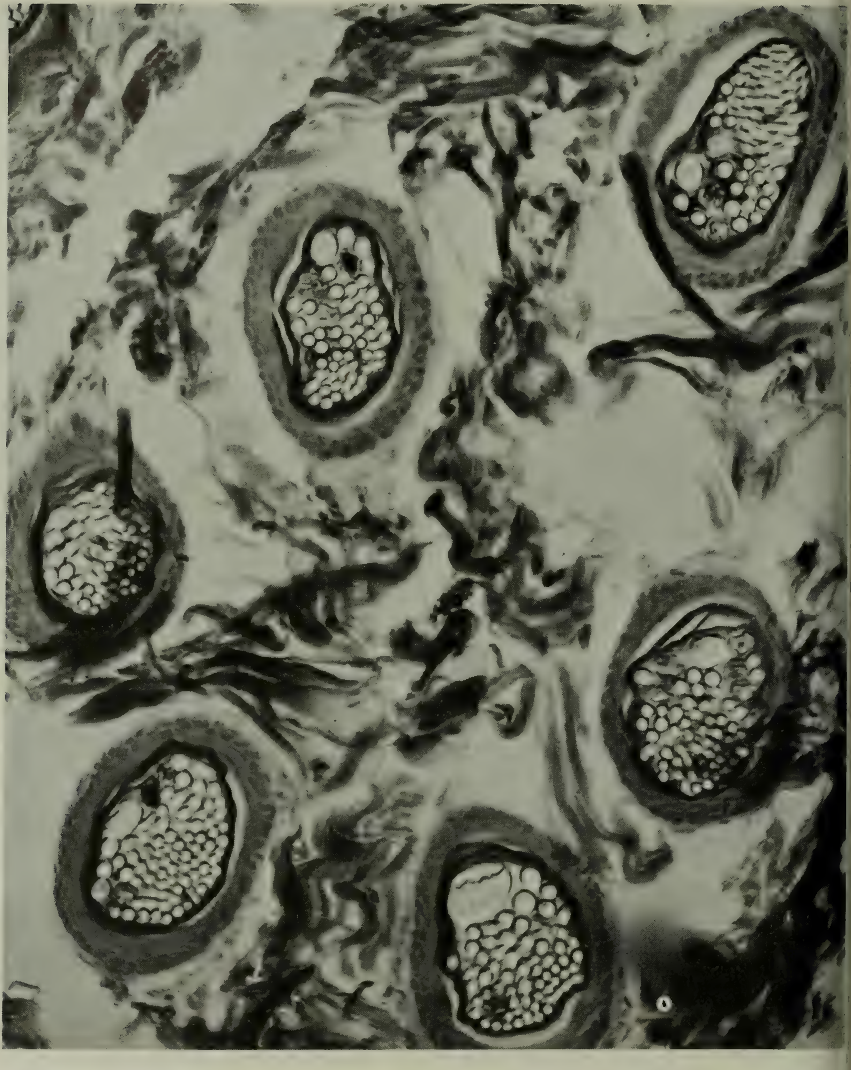


FIGURE 16.—Horizontal section through skin near surface, midback, adul male sea otter D22–57, anterior at top. The large guard hair in each pelag unit may measure 64 microns in diameter. The fur hairs average 7.2 micron in diameter. At this level the hairs are round to slightly oval in cros section. (VBS 5716)

hairs, resembles the pattern in all pinnipeds, especially in the fur seal *Callorhinus* and *Arctocephalus*. Dead underfur hairs probably (?) accumulat from one year to the next in the bundles of older animals as they do i *Callorhinus*. The only evidence is that the count in a young sea otter is 43 a compared to 71 and 91 in two adults. This "reluctant shedding," if actuall a feature of sea otter pelage, would help to maintain a heat-insulating coa

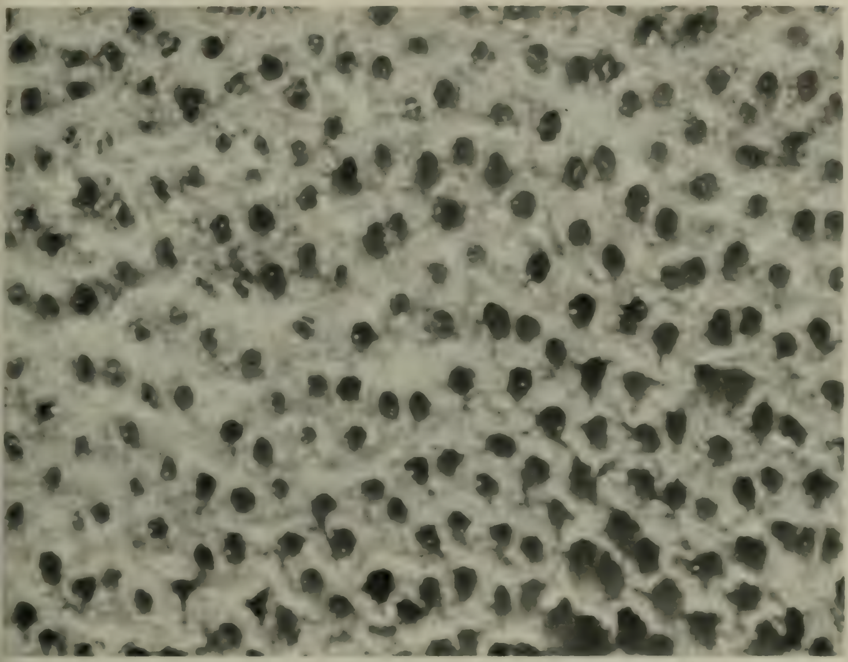


FIGURE 17.—Sheared surface showing skin and distribution of pores from which hair bundles emerge, anterior at top. Sample is from midback, adult male D22–57. Magnification × 24. (VBS 5721)

during molt. The underfur hairs seem to be equal in diameter, though twice as long, as those of *Callorhinus* (Scheffer, 1962, p. 22 and 72). On a disc cut from the fresh skin of an adult female fur seal there are 939 bundles and about 50,000 individual hairs (Scheffer, 1964). On a disc of the same area, though from preserved skin, of the adult male sea otter "Pappy" there are 1,300 bundles and about 100,000 hairs. Because of sampling variables, however, it cannot be said conclusively that the fur of the sea otter is twice as dense as that of the fur seal.

SKIN

John K. Ling (Department of Zoology, Massey University, Palmerston North, New Zealand) contributed the following description, based on examination of a small sample of skin from the facial region of one animal (D22–57).

The formalin-fixed skin was sectioned parallel and at right angles to the skin surface along the hair follicle axes and stained with haematoxylin, eosin, and picric acid. Measurements are uncorrected for *post mortem* changes and are to be regarded as approximate only.

The skin is 3 mm thick from the surface to the panniculus carnosus; the epidermis averages 50 microns in thickness, the papillary layer of the dermis

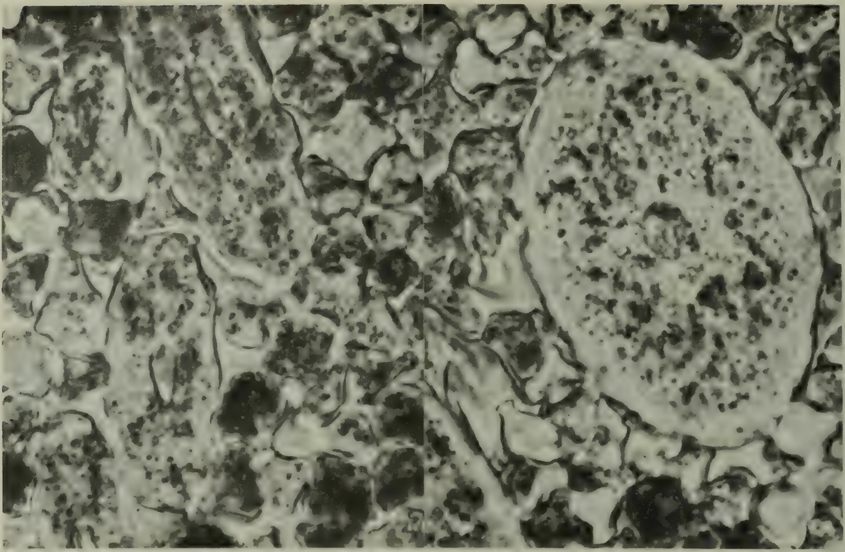


FIGURE 18.—Cross section of pelage (by Hardy device) about 10 mm. from surface of skin, near midback, adult male sea otter D22–57. The large guard hairs are oval in cross section at this level, and their surface is crenulated. The much smaller and numerous fur hairs tend to be 3 or 4 sided. Magnification × 430. (VBS 5712 and 5713)

also 50 microns, and the reticular layer makes up the remainder. The longest underfur hairs measure up to 22 mm in length, of which 19 mm may protrude beyond the surface pore of the hair canals.

Five layers, stratum corneum, stratum granulosum, stratum lucidum, stratum spinosum and stratum germinativum, are recognizable in the epidermis. The granular layer is not uniformly dense throughout and pigment is absent. . . . The epidermis is thrown into a series of folds which are reflected by similar folding of the papillary zone of the dermis. Collagen fibres in the deeper dermis are oriented both randomly and parallel to the skin surface. Arrector pili muscles are absent.

Hair follicles are arranged in bundles and are aligned at an angle of about 70° to the skin surface. Each bundle comprises a guard hair follicle and underfur follicles, which are separated from each other near their base but are held together closely at higher levels. In cross section there is some suggestions of trio grouping with a central guard hair follicle between two other guard hair follicles. The underfur follicles open into the guard hair canal and all hairs emerge at the skin surface through a common pore [fig. 17].

Cutaneous glands associated with each guard hair follicle and opening into the bottom of the guard hair canal comprise a bilobed sebaceous gland and a greatly coiled apocrine sweat gland. The sweat duct opens posterior to, and slightly higher than the common sebaceous duct formed by the union lower down of separate ducts from each gland. Keratohyalin granules abound near e exterior ends of the cutaneous gland ducts. There are no glands opening to the underfur follicles (fig. 19).

Adaptations of the sea otter integument to an aquatic habit include (1) ly periodic occurrence of the granular layer which may confer upon the rny layer different properties from those arising from the continuous esence of granules, thereby contributing to its water-resisting function; (2) e flattened guard hairs; and (3) the absence of arrector pili muscles abling the hairs to lie close to the skin surface when the animal enters the ater. These features are exemplified by the fur seals and they may be mmon to all semi-aquatic mammals. In common with other densely furred ecies the sea otter has large functioning apocrine sweat glands associated ith each guard hair follicle.

nsory vibrissae

Sensory vibrissae are in three locations: mystacial, superciliary, d nasal. The numbers of vibrissae are for the left side only an adult male. There were 8 rows including 62 mystacial vib-ssae (i.e., total both sides 124 mystacial vibrissae). The largest as 53 mm. long and the shortest 2 mm. There were four super-liary vibrissae, the largest (dorsal) was 33 mm. and the three hers were about 12 mm. long. There were three nasal vibrissae long the dorsal anterior nasal area), each about 14 mm. long.

The mystacial vibrissae are the most important as sensory gans. They are voluntarily controlled and are frequently ex-nded forward. In this position they are used as sensory aids hen walking among rocks or when examining a strange object. resumably they are used when exploring the bottom of the sea r food. In the wild they are often worn off short but in captivity, here a search for food is not necessary, they may reach a length 100 to 120 mm.

OLT

Maynard (1898) wrote that "Their fur is considered equally od at all seasons; hence they are hunted throughout the entire ar." Similar statements were made by many other authors.

The lack of an observable molting season may perhaps be ex-ained by analogy with molt in the fur seal. Scheffer and Johnson 963, p. 32) found that "The number of underfur follicles per ndle in the first adult-type pelage . . . remains unchanged roughout life" but that the number of fibers in each bundle creases with age. "The rise in the fiber count means that up to percent of the fibers are not shed in late molt but remain fast the bundle."

Scheffer demonstrated earlier in the present report that a young

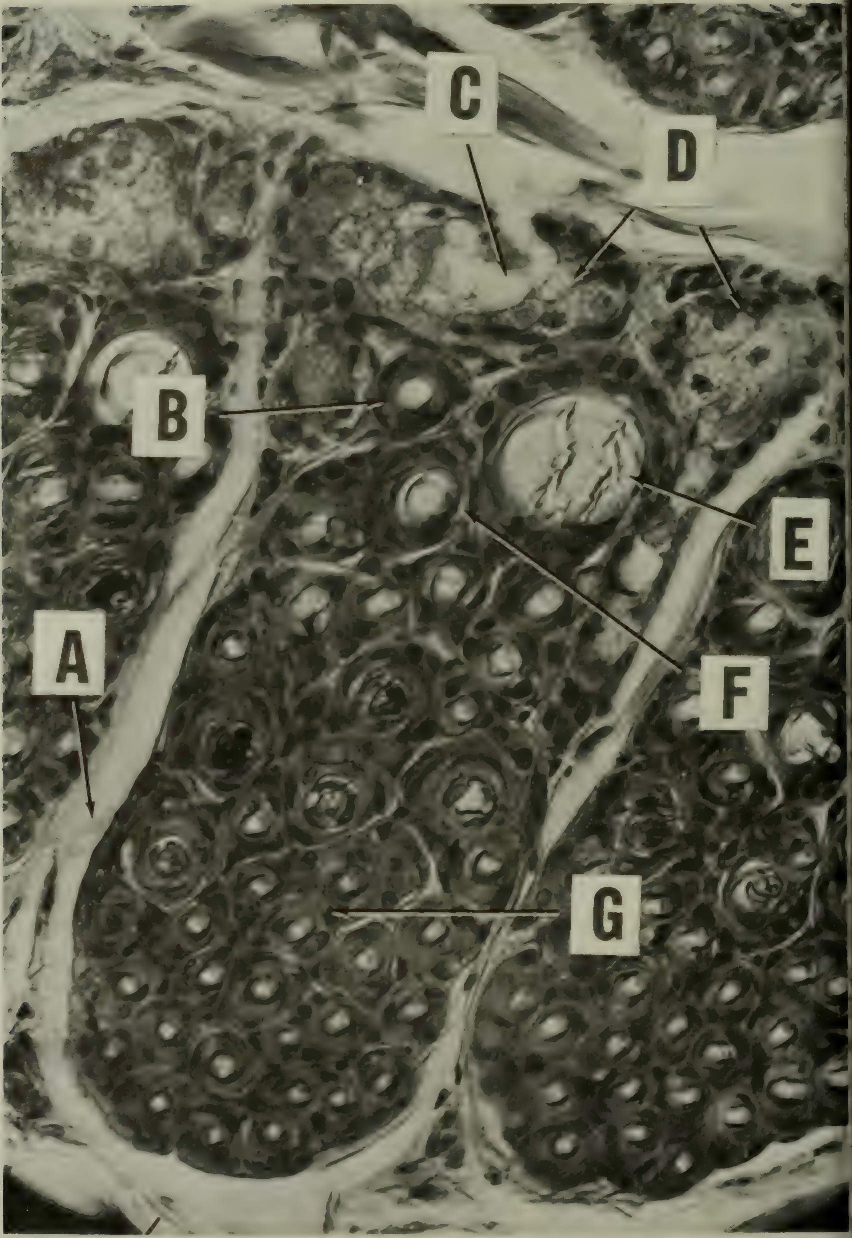


FIGURE 19.—Horizontal section through the sea otter skin showing deepe layer, near hair roots, with one complete pelage unit. *A*—connective tissue *B*—sweat duct, *C*—sebaceous duct, *D*—sebaceous glands, *E*—large guar hair, *F*—large underfur hair, *G*—smaller underfur hairs. (JKL photo)

ea otter in its first adult pelage had fewer fur fibers (43) per undle than two adults (adult male 71 and adult female 91). That he fiber population is denser in the sea otter than in the fur seal adult female 51, adult male 68) is not surprising. Insulation in he fur seal is provided by both blubber and fur but the sea otter, aving no blubber, must depend for insulation only on its fur. It eems reasonable to conclude that fur fibers are retained in the ea otter as they are in the fur seal, thus "masking" the period f molt.

John Vania, Leader, Marine Mammal Studies, Alaska Depart- ent of Fish and Game, visited the Marine Mammal Biological aboratory in Seattle from 8 to 19 November 1966 to work with . B. Scheffer on the examination of skin samples from sea otters. f 26 sea otters taken in winter and 20 taken in summer, all howed evidence of molt in some of the fiber roots. This evidence puzzling; the molt deserves further study. A tentative con- lusion is that, throughout the year, at various places on the body, ndividual fibers are in molt while others are at rest.

Observations of captive sea otters also suggested that the period uring which fur is shed is prolonged. In all seasons fur fibers ere seen on the paws of otters during grooming activity and uantities of fur accumulated at the drain of their pool.

To estimate the periods of maximum and minimum molt, Cecil rosseau, Director, the Tacoma Aquarium, collected samples of ur for me from a screen over the drain of a pool that held an dult male sea otter (Gus). The uniformly collected samples con- isted of the accumulation of fur and guard hair for a 15-hour eriod at 7-day intervals from October 1967 through October 1968. he samples were dried, cleaned manually (fish scales, fragments f bone, and other debris were removed), and weighed on a beam alance to the nearest 0.01 g. The mean weights of the samples r each month show that shedding is maximal in late spring and ummer (mean of 4 August samples = 59 cg.) and minimal in idwinter (mean of 4 January samples = 25 cg.) and that ap- reciable shedding occurs in all months (fig. 20).

This study suggests that the sea otter exhibits one period of aximal follicular activity (molt) annually in the spring and at it may be similar to the European otter (*Lutra lutra*) which said to molt almost imperceptibly during a prolonged period Novikov, 1956), as does the polecat (McCann, 1955).

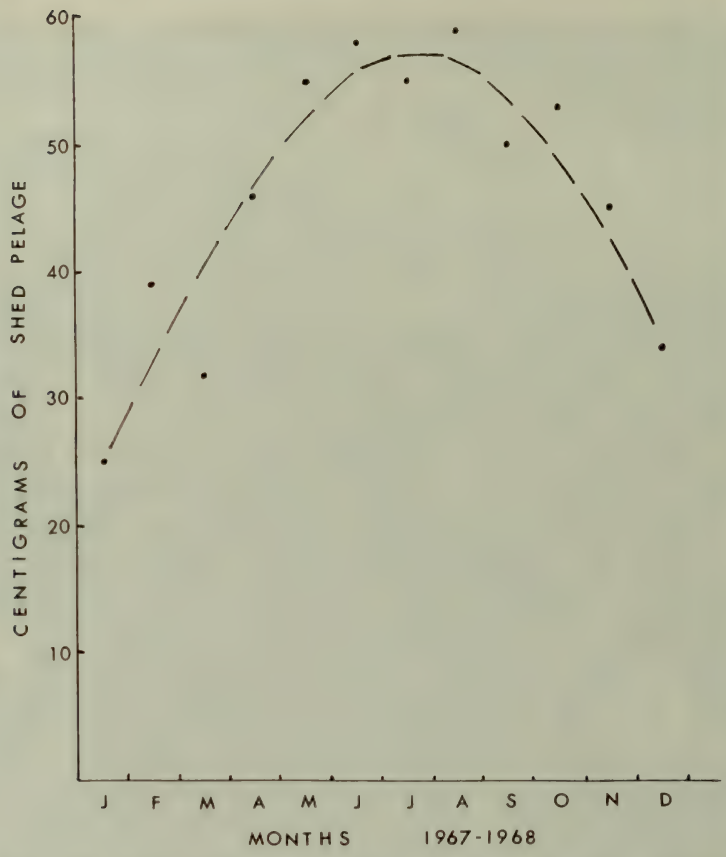


FIGURE 20.—The shed pelage of an adult male sea otter was collected fro the drain of his pool at 7-day intervals from October 1967 to Octobe 1968. The mean weights in centigrams of three to five samples (fou samples were discarded) collected each month are indicated by dots. Th curve shows maximal and minimal periods of shedding during the yea and suggests one annual maximal period of molt.

THE PELT IN COMMERCE

Processing

Concerning the processing of sea otter skins, Poland (1892 stated: "The skins are occasionally smoked, and are also dyed o topped." To clarify the meaning of this statement I wrote to Dr J. L. Stoves of Martin-Rice Ltd., fur processors, London, England and received the following information (letter, 7 May 1963):

> Sea otter fur was dressed in the 19th Century by the conventional method i.e. fatty tissue was removed by scraping or fleshing after which the skin were smeared with grease or oil (butter rejected for human consumptio

> was also used). The greased skins were then trampled underfoot in large barrels or tubs (so called 'tubbing'). Excess grease was removed by tumbling the skins in sawdust contained in revolving drums ('drumming'). After this the leather was reduced in weight by cutting down or shaving (by hand or by machine). The guard hairs were not removed. . . .
>
> With regard to the quotation from Poland's book, he is referring to the colour of the fur. Poor quality furs were sometimes up-graded (temporarily!) by hanging the skins in smoke from a smouldering, smoking fire whereupon a thin film of soot and tarry matter deposited on the fur turned light yellowish fur into a darker richer brown. The effect was purely temporary but was an unethical way of up-grading fur prior to sale.
>
> The remarks on "dyeing or topping" refer to more lasting improvement of colour (after the raw skins have been auctioned) by deliberate use of dyes. These could be applied by immersing the skins in solutions of the metallic mordants and vegetable dyes then used, or alternatively the materials could be applied to the fur only by brushing, i.e. "topping", a method which left the leather undyed and the article then looked more like a better grade skin which had been dressed only.

Skins taken in recent years were tanned by modern conventional methods. In describing the color, a fur dealer who examined several typical specimen pelts used the following terms: "dark brownish underwool," "brown wool," "very silvery-good top hair," "brownish with a greenish cast."

Value of pelts

Fisher (1941a) summarized information on prices paid for sea otter skins from the time of Bering to 1940: In the mid-1700's skins sold for 20 rubles (about $10) in Kamchatka to 100 rubles (about $50) at the Chinese frontier. During the 1880's prices on the London market ranged from about $105 to $165. By 1903, when sea otters had become scarce, extra rich, large skins sold for as much as $1,125. Fisher was unable to verify or find the source of the statement by Evermann (1923) that during the 1920's (after the sea otter received protection) the prices paid for sea otter pelts ranged from $2,000 to $3,000 each. Among 54 confiscated sea otter skins sold at auction for the account of the U.S. Government from 1924 to 1940, the most valuable brought $465. Only 3 skins were sold for more than $400, 7 for $300 to $350, 7 for $200 to $295, 12 for $105 to $190, and the remaining 25 for less than $100. The average price per skin was $148.54.

On 12 April 1957 at public auction, 117 dressed skins sold for the account of the U.S. Government brought an average price of $22.88 per skin (F. G. Ashbrook, letter 29 April 1957).

On 1 January 1968 the first collection of sea otter skins taken for commercial use since 1911 was offered for sale at the Seattle Fur Exchange, Seattle, Wash. The auction was held for the account of the State of Alaska. Among 1,000 available skins, 905 were considered acceptable for commercial use and were offered for sale.

To prepare them for sale the skins were cased (skinned through a single slit along the hind legs from heel to heel) and dried on frames. The pelts were cleaned and brushed and displayed fur side out. They were divided into 197 lots. The lots ranged in size from one to eight skins matched according to size and color. The bid price for a single skin determined the price for all skins in that lot.

Skins taken in 1962 and 1963 and held since then were less valuable, because of depreciation of quality in storage, than pelts taken in 1967. The earlier collection sold for an average price of about $80 each. The more recently taken skins averaged $280 each. One lot of four skins was sold at the maximum price of $2,300 per skin.

The auction was attended by buyers representing 33 companies from 7 states and 6 foreign countries. All skins offered for sale were sold.

Feeding Mechanisms

Dr. Robert P. Scapino, Department of Oral Anatomy, University of Illinois, has undertaken continuing study of the jaw mechanics and feeding behavior in carnivores. He accomplished a preliminary study of the skull and musculature of the sea otter and kindly contributed an anatomical description, excerpts from which are quoted below (letters, 1963 and 1964). He plans an extensive publication on his studies of carnivore feeding mechanisms.

MASTICATORY MUSCLES

I have completed gross dissection of the masticatory musculature in *Enhydra*. The descriptive terminology used is somewhat different than what you will find in works on *Lutra* (Fisher, 1942; Schumacher, 1961), however, the terms used to designate the various muscles are perfectly acceptable and, in my view, the most useful. My division of the superficial temporal muscle into superior and inferior heads is somewhat unusual and later, when I have examined the muscle in a sufficient number of other mustelids, I may decide to label it differently. But right now the separation seems warranted, at least from an anatomical standpoint.

The masseter muscle of carnivores is usually described as having incompletely distinct superficial and deep parts, but in the sea otter these divisions are even more indistinct than usual.

The anatomy of the jaw muscles in *Enhydra* is essentially the same as in her carnivores. Two features of the temporalis, however, are noteworthy. ie superficial temporalis in most other carnivores arises from the entire idersurface of the superficial aponeurosis and is not confined to the anterior rt as in *Enhydra*. Of the carnivores I have examined the only two that are e *Enhydra* in this respect are the mink and river otter.

The inferior head of the superficial temporalis is well developed in *hydra* and distinct from the superficial head. In other carnivores this uscle seems relatively smaller and blends with the superior head. The func- nal significance of these differences is not clear.

ANDIBULAR JOINTS

Most carnivores have three jaw joints. The two temporomandibular joints e obvious, but the third, the symphyseal joint has escaped the serious at- ntion of comparative morphologists. My studies indicate that the latter joint s crucial functions in carnivore jaw mechanisms.

The morphology of the temporomandibular joints in carnivores is distinctive. e condyle of the lower jaw takes the form of a transversely oriented linder that articulates more or less snugly in a trough-like glenoid fossa. e temporomandibular joint of *Enhydra* does not appear significantly differ- t from that of other carnivores.

The symphyseal joint of carnivores is more varied. This joint consistently ws high mobility (i.e., high mobility for carnivores) in those large nivores that are powerful crushers. The mobile type of symphysis typically s relatively flat articulating plates that are separated by a well-developed rocartilagenous cushion along their anterosuperior borders. The symphysis *Enhydra* fits this model. Also in *Enhydra*, the articulating plates are und together by stout cruciate ligaments below and behind the fibrocartilage.

The mobile type of symphysis seems to function to facilitate fitting the th to the object that is to be crushed and the fibrocartilage cushion as a ck absorber to reduce the biting force that is transmitted to the skull when resistance of the object is overcome (Scapino, 1965). The cruciate liga- nts allow symphyseal movement, but stabilize the joint by preventing ect lateral separation of the articulating plates.

The teeth and symphysis of *Enhydra* appear to be primarily adapted for ishing hard objects. The sea otter easily cracks the shells of mollusks with posterior teeth (Kirkpatrick *et al.*, 1955). The combination of a loose nphysis with bunodont teeth in this animal is also observed in other large nivores that are crushers.

ENTITION

The teeth of the sea otter, particularly the molars, are flattened d rounded. They are not adapted to cut or shear flesh but to ish invertebrates, the preferred food. Even the canines are inded, having a blunt point and no sharp edge (fig. 21). Be- ise these are used to open the valves of such organisms as the k oyster (*Pododesmus*) the tips are often worn or broken. sher (1941b) described the dentition of the sea otter on the sis of fragmentary material (particularly from younger ani-

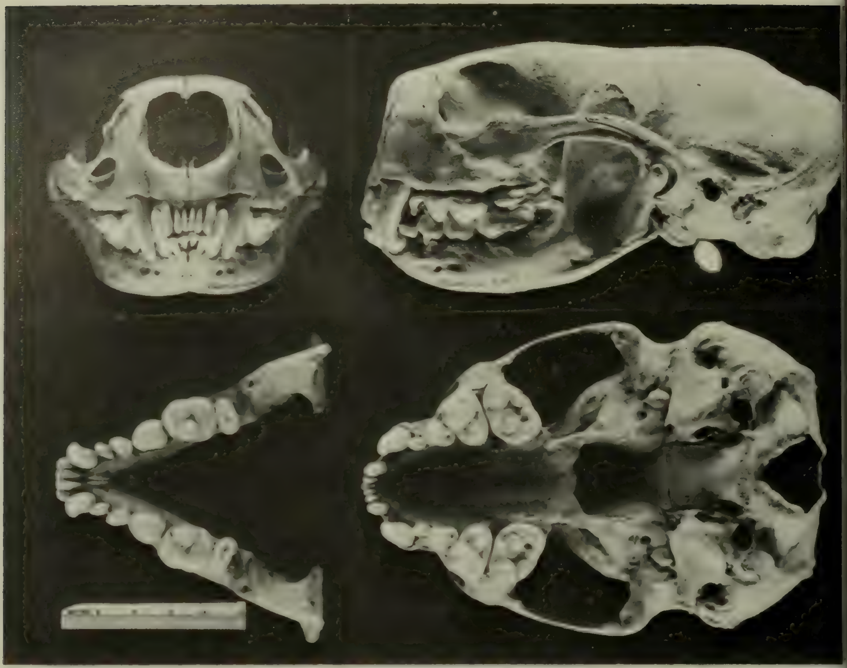


FIGURE 21.—Fresh young adult dentition in the late juvenile or early subadu stage of development. Note the rounded, blunt canines and spade-shape lower incisors which are used to scoop invertebrate organisms from the shells. Found dead on the beach, 5 March 1962, Amchitka Island, Alask weight 24 lb. (10.9 kg.), length 1,005 mm. (KWK 66–9–9)

mals) then available. For this reason, the present description premature dentition differs somewhat from hers.

In the following discussion, the terminology of Scheffer an Kraus (1964, p. 296–298) is used. The ages at which individu teeth erupt are approximations and are based primarily on bod size. A limited number of specimens was studied to determine th progression of tooth eruption from birth to the adult dentitio A detailed study of dental development remains to be undertake

In a newborn sea otter (fig. 22), weight about 1.7 kg. (3.7 lb. the four canine teeth, two upper incisors and two lower first an second pairs of postcanine teeth are erupted from the gums. A birth there are a total of 26 deciduous teeth of which 10 ar visible (see formula). The fate of the fetal teeth that are erupte from the bone at birth but are not gingivally erupted is not know but it appears that they are exfoliated without becoming fun tional.

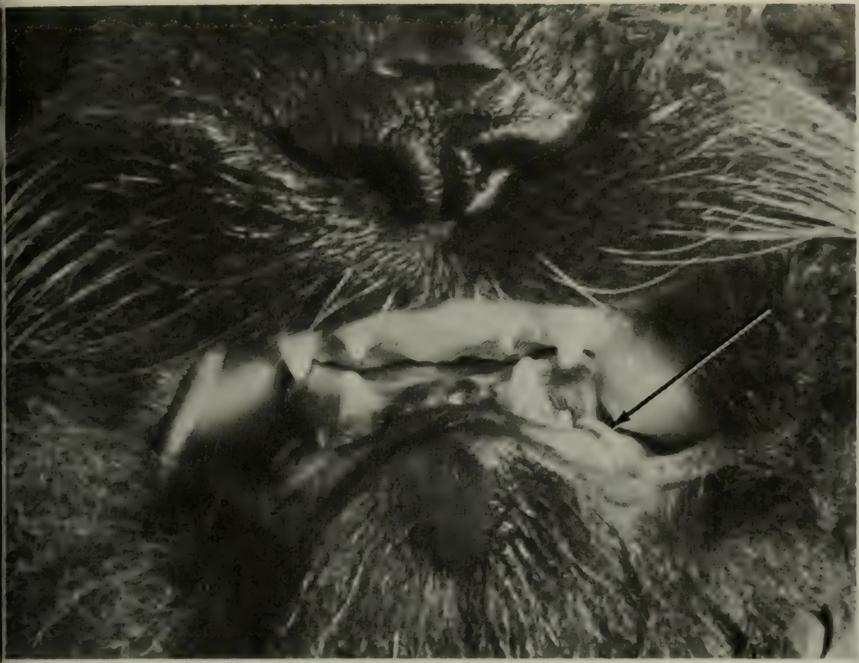


FIGURE 22.—Dentition of newly born male sea otter (62–178), taken at Amchitka Island, 18 February 1962, weight 1.7 kg. (3.7 lb.), length 528 mm. The canines and one pair of upper incisors are clearly shown. The barely erupted first postcanine is visible and the second postcanine is indicated by an arrow. The young sea otter pup probably receives most of its nutrition from mother's milk but soon after birth its mother gives it soft bits of solid food. (KWK 62–14–28)

The complete juvenile dentition (fig. 23), consisting of 44 teeth of which 26 are gingivally erupted, is obtained within about the first 2 to 3 months after birth when the young otter has reached a body weight of about 4 kg. (8–9 lb.). This mixed or transitional dentition is retained for several months.

The complete permanent or adult dentition (fig. 21) consisting of 32 teeth is attained toward the end of the first year of life and before sexual maturity is attained.

The dental formulae given below were determined from skulls that appeared to be typical of the stages of development. These skulls were chosen after examining several dozen specimens.

Dental formulae

Figures represent the number of teeth present on one side; those in parentheses are not yet gingivally erupted. Lower case=deciduous tooth;

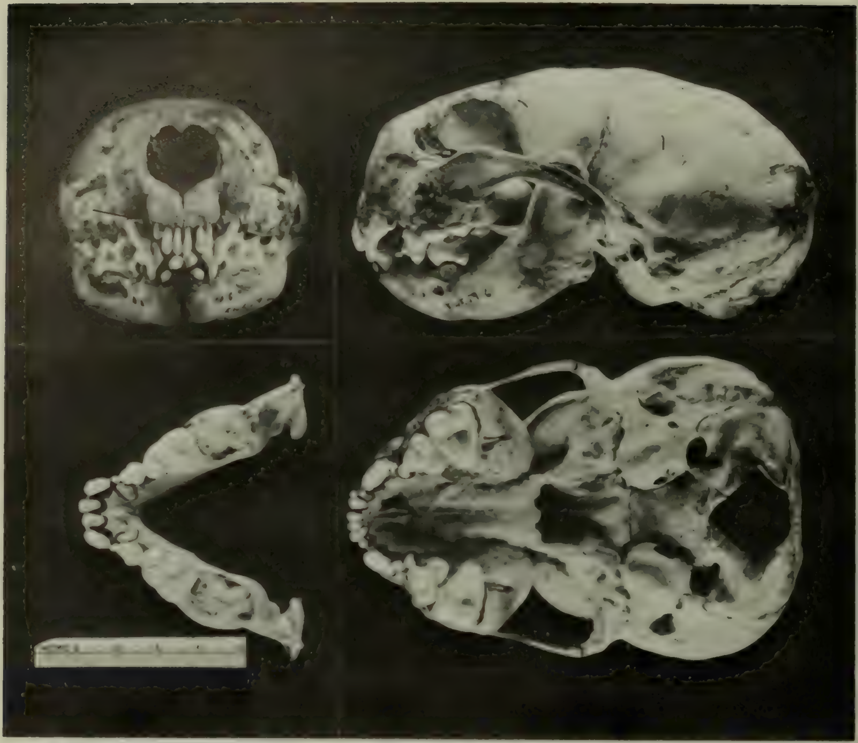


FIGURE 23.—Complete juvenile dentition of a female aged 2 to 3 months, weight 8.75 lb. (3.9 kg.), length 720 mm., captured 12 March 1959. The permanent incisors have all erupted and the permanent first postcanines are erupting and displacing their fetal antecedents. The second and third pairs of deciduous postcanines are well developed. No indication of molar eruption is visible but the tips of the erupting canines are visible (arrow). (KWK 66–11–11)

upper case=permanent tooth, (I=incisor; C=canine; PC=postcanine; M=molar).

Newborn (fig. 24 and fig. 22):

$$i\,\frac{1+(2)}{(2)}\qquad c\,\frac{1}{1}\qquad pc\,\frac{(3)}{2+(1)} = \frac{2+(5)}{4+(2)}$$

Total on one side, 4+(9); total teeth, 26.

Juvenile (mixed or transitional) (fig. 23):

$$\begin{array}{llllllllll}
I & 3 & C & (1) & PC & 1+(2) & M & (1) & & 4+(4)\\
i & \underline{-} & c & \underline{1} & pc & \underline{2} & - & \underline{\quad} & = & \underline{3}\\
i & - & c & 1 & pc & 2 & - & & & 3\\
I & 2 & C & (1) & PC & 1+(2) & M & (2) & & 3+(5)
\end{array}$$

Total on one side, 13+(9); total teeth, 44.

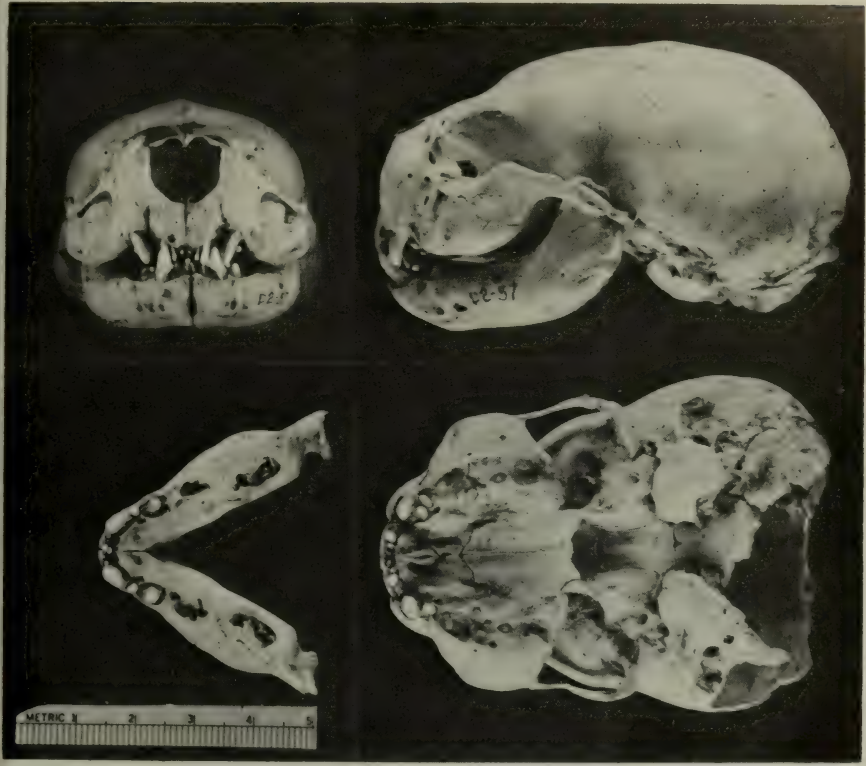


FIGURE 24.—Dentition at birth. The tiny fetal teeth are not erupted from the gums. The canine teeth, a pair of upper incisors, and the first and second pair of lower postcanine teeth are erupted from the gums at birth. Female, captured with mother, Amchitka Island, Alaska, weight 1.5 kg. (3.2 lb.), length 521 mm., umbilical cord attached. (KWK 66–11–2)

Adult (fig. 21):

$$\text{I}\ \frac{3}{2}\qquad \text{C}\ \frac{1}{1}\qquad \text{PC}\ \frac{3}{3}\qquad \text{M}\ \frac{1}{2} = \frac{8}{8}$$

Total on one side, 16; total teeth, 32.

Incisors

At birth the deciduous caniniform incisors (No. 3 pair) are erupted (fig. 22). These are the first functional teeth to be lost, and are replaced after the two central pairs of permanent upper incisors and the two pairs of permanent lower incisors have erupted gingivally at about 2 or 3 months after birth. The four pairs of central incisors are the first permanent teeth. Their antecedents are small and nonfunctional; they are probably shed when the permanent incisors erupt.

As Hildebrand (1954) has pointed out, the spade-shaped and somewhat protruding permanent lower incisors are used to scoop food organisms from their shells when the sea otter is feeding. In older animals they show wear (fig. 25).

The sea otter is the only member of the order Carnivora with only two pairs of lower incisors. In this respect, it resembles the pinnipeds, most of which also have only two pairs of lower incisors. The walrus has no lower incisors in the adult dentition.

Canines

At birth the deciduous canines are erupted. They are shed and replaced following the loss and replacement of the deciduous caniniform incisors at about 5–6 months of age.

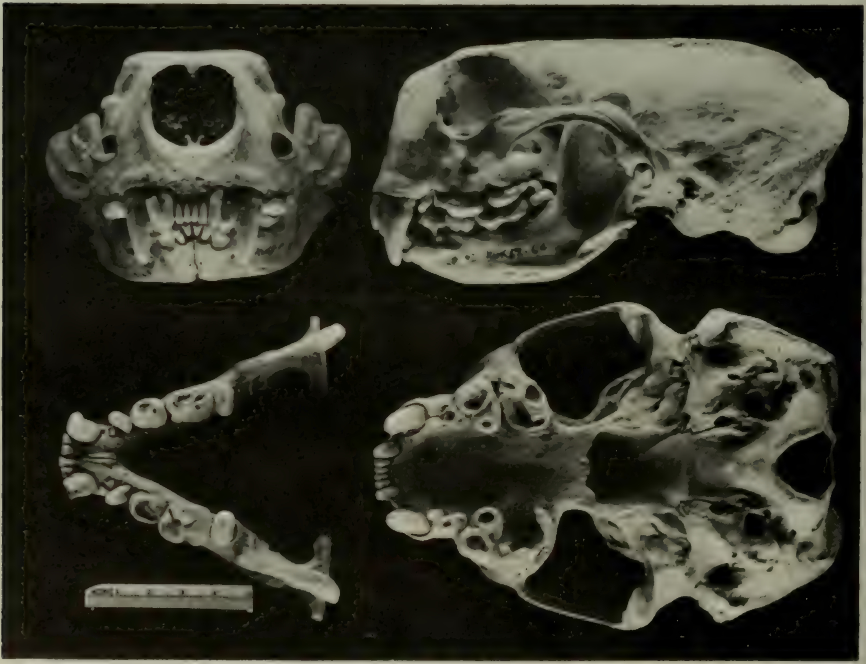
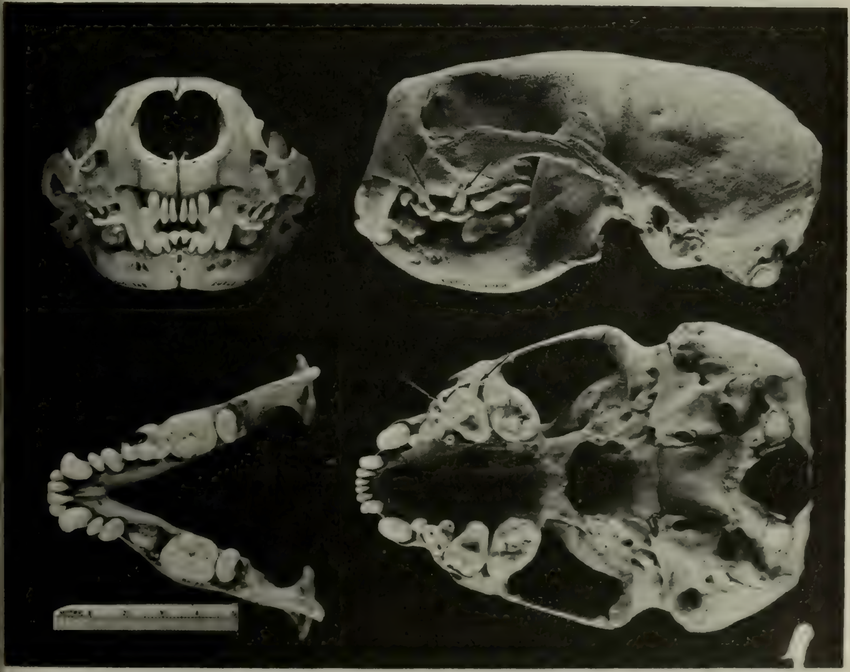


FIGURE 25.—"Old" adult dentition. No method of determining chronological age has been found, but animals with severely worn teeth like this were classified as "old." The worn lower incisors and canines and severely eroded postcanines and molars result when hard-shelled organisms are crushed by the teeth. This male, weight 55 lb. (25 kg.), length 1,420 mm., was captured on a beach at Amchitka Island, 14 March 1959. (KWK 66–12–10)

ostcanines

The deciduous lower 1st and 2d postcanines are erupted at birth. he other four pairs erupt a few weeks later. The postcanines are e last deciduous teeth to be replaced by permanent teeth, at an timated age of 8 to 12 months. The 2d and 3d permanent post-nines erupt in the last quarter of the first year of life. These re the last of the permanent teeth to erupt. As they push upward e deciduous postcanines are raised above their neighbors but main anchored to the alveolar bone for a considerable period. his condition results in poor occlusion of all tooth surfaces ig. 26).



IGURE 26.—Intermediate juvenile-adult dentition. At this stage the incisors, two pairs of lower postcanines, one pair of upper postcanines, and molars of the adult dentition are almost fully erupted. The remaining postcanines of the juvenile dentition, however, are still held in place by their extended roots (arrows) above the erupting permanent teeth. The upper photographs demonstrate that these teeth prevent occlusion of the molars and incisors. Many young at this stage are found dead of starvation on beaches. Note abrasion-caused attrition of juvenile teeth. (Juvenile female 62–208, weight 22 lb. (10 kg.), length 1,000 mm., found dead on beach, 5 March 1962. (KWK 66–10–15)

Molars

The upper and lower molars have no antecedents. They erupt in the late juvenile period somewhat later than the permanent canines and somewhat earlier than the permanent postcanines.

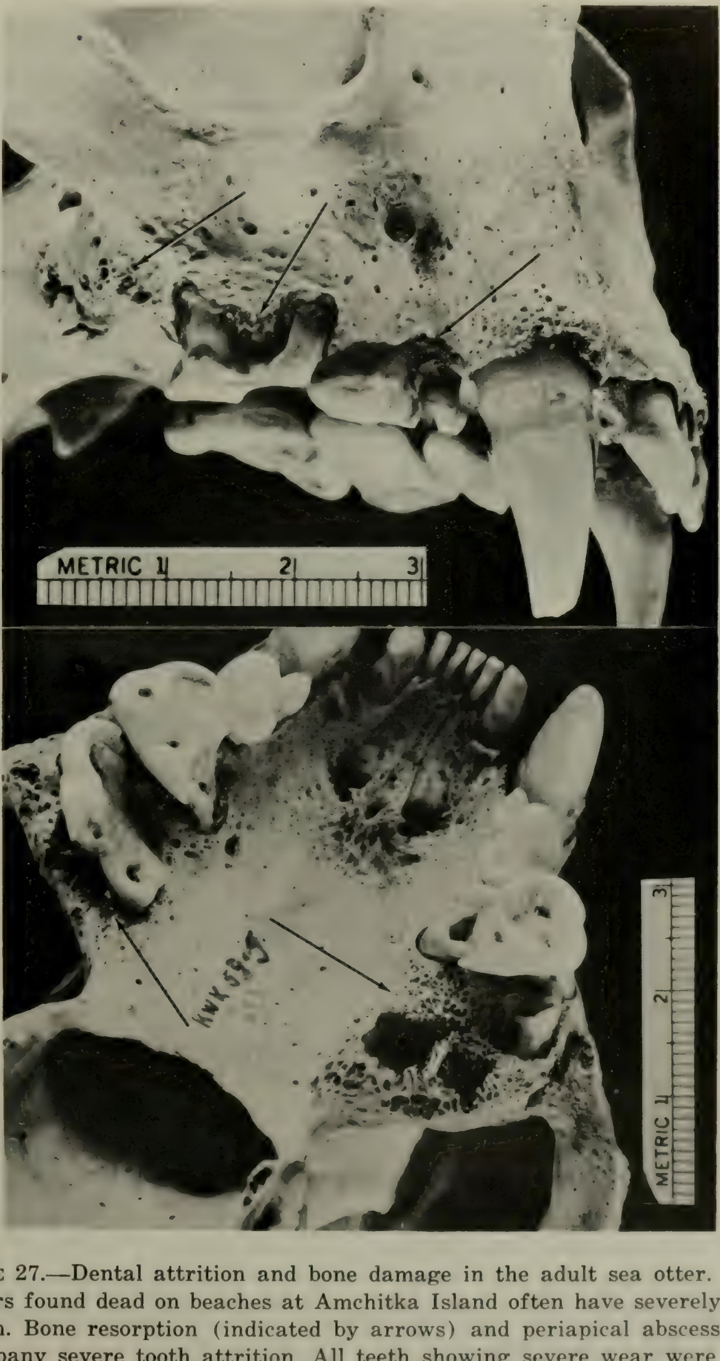
Many young are born in the late winter-spring period. In the following late winter and early spring period of stress, the food intake of these large juveniles is inhibited by the eruption of the permanent postcanine teeth and the accompanying loss of deciduous teeth. In the crowded Amchitka population where food resources are heavily exploited, such young, still dependent on their mothers for much of their food, are deserted and die at this time. Apparently, the mothers are unable to supply the food needs of both themselves and their large young during this season of stress.

Because poor occlusion, as described above, was observed in many young otters found dead of starvation on beaches, it was assumed that this condition was a factor in their failure to survive (see Mortality Factors).

Dental attrition

The teeth of many sea otters at Amchitka Island show severe tooth wear (fig. 27). In order to learn something of the nature of this damage, sample skulls with worn teeth were sent to Dr. David B. Scott, Chief, Laboratory of Histology and Pathology, National Institute of Dental Research. After he and his associates had examined the teeth they contributed information in a letter of 23 May 1963. Excerpts are quoted:

> None of us feels that the pitted and worn areas have the requisite characteristics of dental caries. The alterations are quite curious. Since we were not familiar with the dentition in the otter, we removed an unerupted permanent tooth and uncovered two others from under the deciduous teeth of a juvenile male (KWK 59–105), and also removed one of the more interesting atypically pitted ones from an adult female (KWK 59–11). One of the former teeth split well enough for us to get an idea of the enamel thickness; taken together with the appearance of the other permanent teeth in this young skull the impression is gained that deep pitting is not a feature at the outset.
>
> The most interesting and confusing configuration in the pitting of the type found in the tooth from KWK 59–11, is the tips of the cusps. As seen in the sectioned tooth, the hole in the underlying dentin is actually broader than the opening through the enamel, resulting in a sort of undermining. [Examination of many teeth indicate to me that these pits are formed when a piece of hard sand is pressed into a newly formed break in the enamel. Movement of the sand grain and pressure on it when food is chewed cause it to rotate and create a cavity in the dentin larger than the hole through which it entered.] This is not expected in attrition, but all of us feel that the classical signs of caries are not present. There is quite a deposit of secondary dentin



IGURE 27.—Dental attrition and bone damage in the adult sea otter. Adult otters found dead on beaches at Amchitka Island often have severely worn teeth. Bone resorption (indicated by arrows) and periapical abscesses accompany severe tooth attrition. All teeth showing severe wear were loose. The crushing of hard-shelled organisms, such as mussels and sea urchins, is a suggested cause of severe tooth wear. (KWK 66–14–10 above, 66–13–20 below)

in the pulp chamber beneath the large pit that has resulted in obliteration of the pulpal horn. This phenomenon is ordinarily considered as a defense reaction against trauma or caries. Looking at these pits and the more advanced damage in the other skulls, we are tempted to conclude that some sort of peculiar attritional sequence is represented. The later flattening can be more easily explained in the usual terms of wear and tear. I suspect that a rather large-scale study would be required before the facts could be ascertained as to how the early pitting occurs.

There is a good bit of calculus on the teeth. The bone resorption in an adult female (KWK 59–153) suggests that there may have been periapical abscesses in the lower left molar region, probably as a result of pulp exposure from the attrition. The bone damage in the upper left posterior region could be explained in the same way, or equally well as an outcome of periodontal disease. There are also other areas of bone damage.

Tooth attrition and its relationship to feeding habits and mortality at Amchitka Island are discussed elsewhere. It is apparent that a dense otter population at Amchitka has resulted in a shortage of soft-bodied invertebrate food species. Hard-shelled forms are eaten in large quantities. Sea otters often chew mussels *(Mytilus)* and sea urchins *(Strongylocentrotus)*. The sounds of shells crushed by the teeth are often audible for many meters. Also, sand is ingested with food organisms and sand grains are often found imbedded in teeth.

Dental attrition is less prevalent in sea otters from areas having uncrowded populations than from the crowded Amchitka area. A captive female sea otter that was fed primarily on soft foods showed no dental attrition when she died at the age of about 7 years. It is thus concluded that dental attrition of the kind found at Amchitka is the result of a diet that includes many hard-shelled organisms with which abrasive sand, and even rocks are taken (see Food and Feeding Behavior).

Age Determination

The chronological ages of certain wild animals may be ascertained from anatomical specimens. In pinnipeds the teeth show rings or annuli (Scheffer, 1950a) which are related to cyclical annual phases of fasting and feeding. Similar growth layers are found in the ear plugs and baleen plates of whales (Ichihara, 1966) and in bones (Chapskii, 1952). To a limited degree of accuracy, eye lens weights may indicate age in long-lived mammals, such as the fur seal (Bauer, Johnson, and Scheffer, 1964).

In any study of age determination in mammals it is desirable to have a collection of known-age specimens. The isolation of sea tter populations, problems yet unsolved in keeping a captive olony, and the fact that a regular annual harvest of wild animals as not been taken, have prevented the accumulation of known-ge specimens.

Lacking such basic material, but drawing on his experience in e study of teeth for indications of growth layers and age esti-ation, V. B. Scheffer studied a number of sea otter teeth from oung and old animals. Techniques that reveal growth layers in eth of other mammals revealed nothing that could be related to e annual growth cycle in the sea otter.

Dr. A. F. Forziati and Mrs. M. P. Kumpula, Research Division the American Dental Association, National Bureau of Stand-rds, Washington, D.C., undertook a study of sea otter teeth. eeth were sectioned and subjected to techniques such as X-ray hotography and exposure to ultraviolet radiation. These and her techniques useful in revealing growth layers in other mam-alian teeth showed faint lines (fig. 28) but gave no useful in-ication of annual growth layers.

In a further effort to "mark" stages of tooth growth, three ptive sea otters on Amchitka Island were injected periodically ring a 3-month period with alizarin red S dye. It was hoped that sible growth lines would be formed. When the teeth of these imals were studied by Dr. Forziati and Mrs. Kumpula, how-er, no consistent markings were revealed. Further studies of ructures that may indicate age in the sea otter are reserved r the future.

Karl Schneider, Alaska Department of Game (letter, Nov. 1968), lls me that he experimented with a number of different stains d techniques and is now able to differentiate cementum layers hich appear to indicate age.

The sea otter is a permanent resident in a relatively uniform vironment. It requires a daily food intake of uniform amount captive consumed 15 lb. [6.8 kg.] of food per day during all asons). There is no abrupt molt or distinct period of fasting. the absence of marked seasonal environmental changes or riodic metabolic changes during the sea otter's life, it is not rprising that the usual indicators of chronological age are not ident.

One captive otter (Susie) was about 1 year old when captured d died of abnormal causes after 6 years in captivity. Her teeth d bone structure at death appeared to be those of a young adult. n this basis it is estimated that in ideal habitat a wild sea otter ight be expected to live for from 15 to 20 years. A captive river

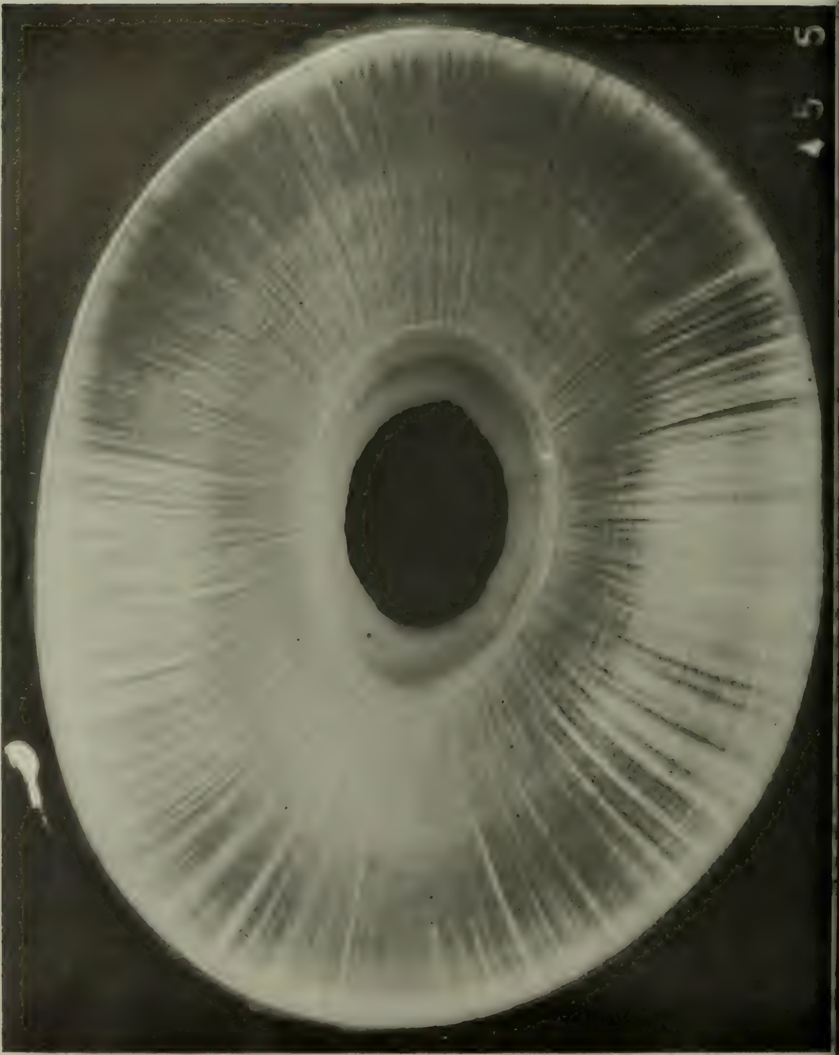


FIGURE 28.—Cross section of the right upper canine tooth of an adult fema sea otter, weight 47 lb. (21.3 kg.) taken at Amchitka Island, 12 June 195 Although various zones and lines are revealed by refracted light in th thin section, no series or rhythm of growth layers relating to the annu cycle could be defined. No technique is yet developed to reveal chronologic age from a study of the teeth. (National Bureau of Standards pho 45–56)

ter lived to the age of "14 years and 4 or 5 months" (Scheffer, 958).

The Senses

The various senses are mentioned or discussed in context under fferent subject headings in other parts of the text. A brief ımmary of observations of the use of the senses is given below.

GHT AND SMELL

The sense of sight appears moderately well developed but, on nd at least, is less important than smell as a warning sense. The llowing observation illustrates this:

> pproached a dispersed group of 25 otters sleeping on the rocks. The S. W. eeze of ca. 4–6 knots was such that I could approach cross wind. I moved ietly to within about 10 feet of a group of six sleeping animals and made a ise to awaken them. The animals looked at me but were not alarmed. After king photos I made some quick movements and they became mildly alarmed d went slowly to the water which was in a channel about 15 feet wide ıong the rocks. Here they preened—not alarmed. Then they swam slowly a point directly down wind of me. As they got my scent, all dived in great rm and swam frantically away under water.
>
> One old male awoke of his own accord and walked leisurely over the rocks my upwind side. He was only 3 feet away. He looked at me with no cognition—I moved slowly and took a picture, the click startled him but he s not alarmed and ambled around behind me, to a point downwind of me. hen he caught my scent he took extreme alarm and scrambled frantically er the rocks, dived into the water, and did not come up until 100 feet away. ield notes, 12 March 1962, East Cape, Amchitka Island, Alaska.)

When otters feeding or resting in the water are approached by human observer and the wind is blowing from the observer to e otters, they become restless. Feeding and resting animals rise gh in the water and sniff the air. Although there is no rapid ovements or indication of alarm, it is generally true that all ıimals will leave the area within about 10 minutes after the observer's arrival. In the same locations, when the wind blows from e otters toward the observer, the otters remain unconcerned even ough the observer moves about on land in clear view.

As mentioned under "Food and Feeding Behavior," sight under ater may be useful in finding food. Gentry and Peterson (1967) monstrated that a sea otter was capable of quite a high degree of curacy in distinguishing, under water, the size of experimental sks.

HEARING

No observation that I know of demonstrates that the sense o hearing is either particularly acute or poor. The sound of a camer shutter clicking at a distance of 3 to 5 m. usually causes an otte to glance alertly about, but does not cause alarm. Both wild an captive otters soon become accustomed to routine sounds of huma activity.

TASTE

Captive otters, when given a variety of foods, often licked eac item, then went back to eat first the food which they apparentl considered most tasty. Certain foods were obviously preferre presumably because of their taste.

TOUCH

The forepaws and vibrissae appear to be very sensitive, an they are important in finding food (see Food Gathering an Sensory Vibrissae).

HABITAT REQUIREMENTS

Sea otters inhabit waters of the open coast of the North Pacific Ocean. Although they enter bays on outer sea coasts, there is no evidence that they ever occupied inland waters far from the sea, such as Puget Sound and the extensive inside passages of the Alexander Archipelago of Southeastern Alaska.

They obtain food from the ocean bottom and are seldom seen in waters deeper than 30 fathoms (54 m.), indicating that this may be the approximate limit of their feeding habitat.

Since sea otters are often seen sleeping and diving for food in and near kelp beds *(Alaria, Macrocystis,* and *Nereocystis)*, it has often been assumed that kelp beds are a habitat requirement. That this is not true is demonstrated by the fact that a large, permanent sea otter population remains throughout the year in the Bering Sea off Unimak Island and off the western tip of the Alaska Peninsula. There are no kelp beds here and in certain other areas occupied by permanent sea otter populations.

In general, however, sea otters favor waters adjacent to rocky coasts near points of land, or large bays where kelp beds occur. Coasts adjacent to extensive areas of underwater reefs are particularly attractive. In such areas, especially where large rocks or islets are located near shore, some feeding and resting areas are sheltered from wind and storm waves regardless of their direction (fig. 29).

In the Aleutian and Shumagin Islands sea otters regularly haul out on land and they may do so elsewhere. Rocky points are favored but sand beaches, islets, or spits are sometimes used. When a sea otter comes ashore it usually remains within about 1 to 6 m. of the water. Where human disturbance is minimal, as on some Aleutian islands, I have found them sleeping in grass *(Elymus)* as far as 50 to 75 m. from the water. Sea otters tend to concentrate and form colonies in areas which offer an abundant invertebrate bottom fauna and sheltered feeding and resting areas.

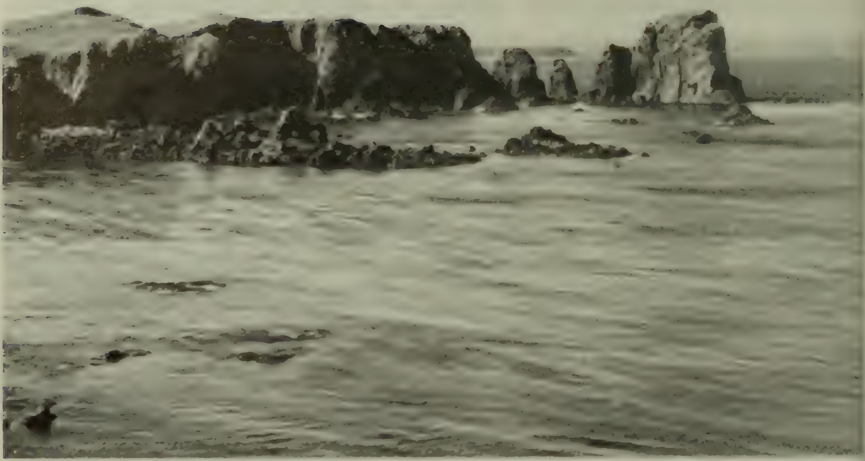


FIGURE 29.—Favored sea otter habitat in the Aleutian Islands is characterized by having extensive underwater reefs to a depth of about 20 fathoms, kelp beds, and points of land or offshore rocks that give shelter during storms. This photograph shows an example of favored habitat on Kirilof Bay at Amchitka Island, Alaska. (KWK 55–16–35)

GENERAL BEHAVIOR

Observations of the habits and characteristic behavior of sea tters were obtained in their natural habitat and in captivity. uantitative studies of behavior and experimental studies were ndertaken in only a limited way (Gentry and Peterson, 1967; nd in section "In Captivity"). Certain characteristic habits and ehavioral traits are discussed in context as they relate to various ubjects in other sections of this report.

Daily Cycle of Activity

It was shown in the section "In Captivity" that when an abunant food supply was available a captive animal spent relatively ttle time feeding as compared to a wild otter. It appears that the bundance of food in the wild also strongly influences the daily ycle of activity of otters in different areas of the Aleutian Islands.

In general, at Amchitka, otters begin to dive for food within he first hour after sunrise. Feeding, interspersed with short eriods of grooming and rest, then continues until mid- or late-morning. Sometime between 1100 and 1300 the otters sleep or oze, usually while floating on their backs in a kelp bed. The duraion of this rest period usually varies from about one-half to three-uarters of an hour. One mated pair rested from 1225 to 1302 (37 minutes). After this nap, feeding, interspersed with short rest eriods for preening and grooming the fur, continues until mid-fternoon when the otters may sleep soundly, usually while floatng, but in male areas a number of animals may haul out for the fternoon nap. This nap usually continues for about an hour. The ame pair mentioned above rested from 1446 to 1548 (62 minutes).

After this rest period, feeding again occurs and may continue ntil sunset or after. At dark or shortly before, some animals haul ut to sleep, usually within a meter or two of the water but on are occasions as far as 75 m. up on the beach. Others spend part r all of the night sleeping in a kelp bed while floating on the ack.

In areas where populations are less crowded than at Amchitka, nd presumably food is more abundant, general observations indicate that rest periods are of longer duration because food nee may be satisfied in a relatively short time.

Mothers accompanied by young, especially large young at A chitka, often continued to dive for food long after all other otte in the general vicinity had retired for the night. On several occ sions I watched mothers feeding until they were obscured by dar ness. This is another indication that food species in the Amchit habitat have been overutilized by that local population. To obta sufficient food for herself and her young, a mother must search f it after other otters have retired.

The general daily cycle of behavior described above contin throughout the year. When prolonged storms create violent wa action, the daily cycle is disrupted and animals unable to obta sufficient food die (see Mortality Factors).

Locomotion

SWIMMING

Methods of swimming

Taylor (1914, p. 491) pointed out that the outer or fifth dig of the sea otter's hind foot is the longest (fig. 8). In this respe the sea otter differs from its nearest relative the river otter, fro seals, and from most if not all land carnivores. He considered th "extra support" (presumably in walking) is furnished by th unusual feature. Howell (1930, p. 284–287), however, after stud ing the musculature of the pelvic limbs, surmised that the s otter swims by means of vertical undulations of the posterior pa of the body; that it uses the hind flippers held in the horizont plane, palms up, in combination with the tail to "present in a sati factory degree the lunate rear border theoretically desirable Thus, "the long fifth toes would form the outer borders of th swimming organ." He was unable to confirm this theory by obse vation. He felt some doubt as to its validity because "It is true th no other mammal is known ever to have employed this method swimming."

On many occasions, from boats and cliffs, and in captivity, have watched sea otters swimming in clear water beneath the su face. Howell's deductions were entirely correct.

While the sea otter is swimming beneath the surface or divin vertical undulatory movements of the body, as described abov furnish propulsion. While near the bottom, maneuvering an searching for food, stroking or paddling movements of the hind flippers are also used.

Unlike other marine mammals, the sea otter habitually swims on the surface when it is moving from one area to another. It usually swims on its back and paddles with alternate strokes of its hind flippers (fig. 30). In this position the long fifth digit dips most deeply into the water and in combination with the other webbed digits produces forward motion.

Thus, the fifth digit is a useful adaptation to two unusual methods of swimming in a mammal: (1) Progression beneath the surface through undulations of the hind flippers and tail in the vertical plane, and (2) progression on the surface by paddling while resting on the back. Whether the fifth digit became elongated as an adaptation to swimming beneath the surface or as the dominant member used in surface propulsion is difficult to surmise.

The sea otter infrequently swims belly down at the surface, with the head and shoulders above the surface (fig. 86). At such

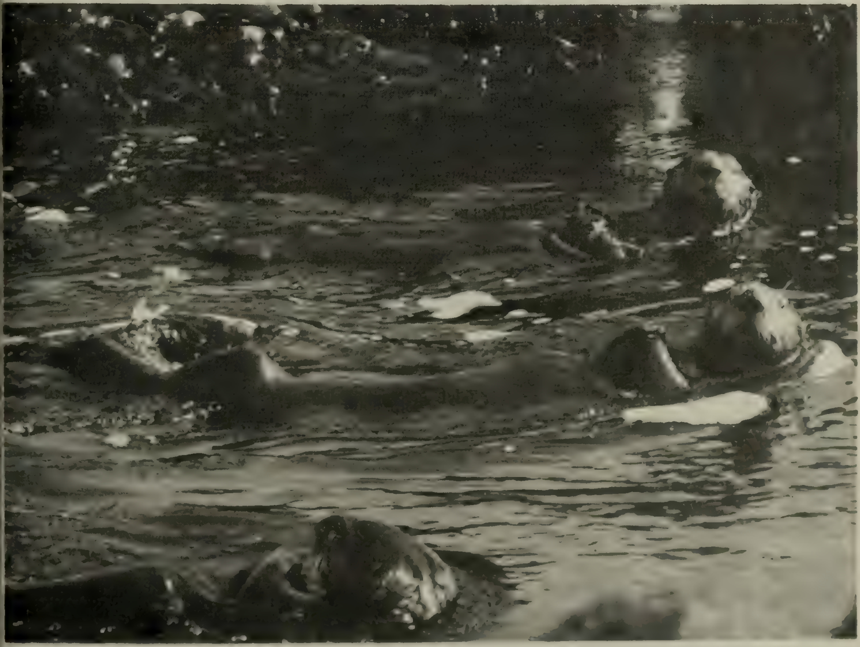


FIGURE 30.—Three adult males in typical swimming attitude. The forepaws are folded across the chest or pressed palmside down against the chest. Forward progress is obtained by alternate strokes of the hind flippers. Maximum sustained surface speed is about 2.5 km per hour (1.5 knots). (KWK 62–27–14)

times the hind feet are used to deliver paddling strokes similar to the stroking movements employed when swimming on the back. Progress on the surface appears to be slower when swimming on the belly than while swimming on the back.

The front feet are not used in swimming either on the surface or beneath it. They are pressed palmside down against the chest or folded across the chest when not in use to manipulate food or to preen the fur or hold young (fig. 30).

The tail is flattened in the horizontal plane and tapers only slightly, so that it presents a broad surface for most of its length. The tail of an adult female measured 317 mm. long, 44 mm. thick, and 64 mm. wide near its base. In addition to its use in conjunction with the hind flippers in underwater swimming, the tail is used as a "sculling oar." Slight alterations of positions are made when the otter is floating on its back. Frequently I observed resting otters floating in this position with front and hind feet folded on the chest and abdomen. Normally the tail floats on the surface while the otter rests, but if it wishes to make slight movements, for example to face away from a light breeze, the tail is projected downwards and by means of circular sideward movements the body is rotated in the desired direction. Also, when captives were eating and they wished to pivot about on the surface to avoid food pilferage by other otters, the tail was used in sculling to assist the stroking hind flippers.

Swimming speed and agility

The sea otter is a slow swimmer but it moves more rapidly beneath the water than on its surface. Two methods were used to measure swimming speed: (1) From the shore, otters traveling from one area to another were timed as they passed beach points. The distances were then measured on nautical charts and the speed computed. (2) Otters were pursued with a motor-driven dory while they swam beneath the surface. In clear water the otters could sometimes be seen as they attempted to escape pursuit. Presumably, at such times they moved at maximum velocity. The speed of the dory was measured by timing its passage over a known distance.

Examples, surface speed: (1) An adult female swam parallel to the coast of Kirilof Point on a nearly windless day. For the most part she swam on her back but occasionally she rolled over and "porpoised" (exposing the back, but not leaving the water) for 10 to 15 yards. During the observation period she made one food dive and when she emerged ate the several urchins she had gathered while she continued on course at the surface. In 44 minutes she covered exactly 1 nautical mile, thus her speed was 2.3 km. per hour (1.4 knots). (2) An adult female, carrying a sleeping pup on her chest, moved hurriedly and steadily on the surface from an area where a rising wind caused rough water. The wind was from her side, so she was neither swimming with or against it. She passed over a measured distance of about 800 m. in 20 minutes, or at the rate of 2.4 km. per hour (1.5 knots). (3) After emerging from a food dive with a fish (weighing about 0.5 kg.), an adult male swam on his back while he consumed the fish and moved with moderate speed to another area. His departure from the feeding area was apparently prompted, to some degree at least, by the presence of three Glaucous-winged Gulls *(Larus glaucescens)* which swam beside or flew above him while they retrieved discarded fish scraps. The otter was able to outdistance the birds that alighted beside him on the water. In 675 seconds he traversed a measured distance of 300 m. at an average speed of 1.6 km. per hour (0.9 knots).

The top speed of our dory was approximately 11 km. per hour (6 knots). On many occasions we chased sea otters in order to catch them in a dip net. When the water was clear and smooth, we could watch the otters swimming beneath the surface as they attempted to escape. It appeared that their top speed for brief intervals, less than 1 minute, was not more than 9.25 km. per hour (5 knots) and probably somewhat less. When we were unable to see otters beneath the surface, we often overran them. Occasionally during escape attempts, otters would porpoise clear of the water ahead of the boat. When this was done they were most readily captured.

Thus it appears that when an otter moves from one area to another on the surface, its near maximum sustained rate of travel may approach 2.5 km. per hour and the underwater, briefly maintained (up to about 1 minute), maximum escape speed is about 9 km. per hour. This compares with a near maximum, briefly sustained (3 to 5 minutes), escape speed of the northern fur seal, which we pursued in a vessel having a maximum speed of 26 km. per hour (14 knots), of about 18.5 km. per hour (10 knots). A Pacific bottlenose porpoise (*Tursiops gilli*) sustained a speed of 29 km. per hour (16.1 knots) for 7.5 seconds (Lang and Norris, 1965).

Although a slow swimmer, the sea otter is remarkably agile. On one occasion I plunged the dip net directly in the path of an otter as it swam just ahead of the dory and at a depth of about ½ m. The otter, unable to avoid entering the net, rolled forward, completed a 180° reversal of course, and escaped before I could pull the net from the water.

DIVING

Duration of food dives

In water depths ranging from about 2 to 25 m. food dives were timed with a stop watch from observation points on the cliffs of Amchitka. Several factors render such observations somewhat difficult to obtain and evaluate. Usually several otters were diving for food in an area under observation. Although an otter may make several food dives in a rather limited area, perhaps 15 m. in diameter, the animal may unexpectedly move 100 m. or more beneath the surface to a new feeding location. Also, a nearby otter may move to the vicinity of an animal that is being timed, causing confusion. The positive identification of the sex of a diving otter is sometimes difficult to ascertain at the distances and with the frequent poor visibility caused by weather conditions.

General observations indicate that the duration of food dives by adult males exceeds that of adult females. The following data probably exaggerate this difference because the females' dives were, to a greater extent than the males', in shallow water:

		Duration of food dives (seconds)			
	Number of animals observed	Timed food dives	Average duration of dives	Maximum duration	Minimum duration
Adult male	4	20	100	160	72
Adult female	6	41	49	82	15

The few observations presented are not strictly comparable, because water depth varied and the animals under observation may have had differing food preferences which caused some of them to search longer for a particular item. Males feed on fish to a greater extent than females. Among 50 stomachs of adult males which contained food, 82 percent contained fish, and 62 percent of 178 stomachs of adult females contained fish. The search for and capture of fish would probably require more time than the gathering of invertebrates.

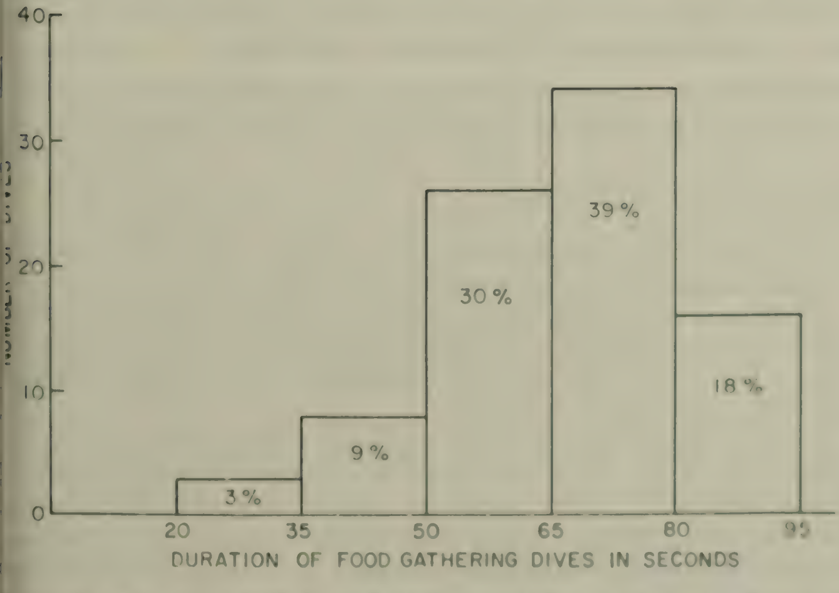
The best data on the duration of dives of the female were obtained on 20 and 21 August 1955. On these two days a mated pair of otters remained in a small cove at Amchitka and no other otters fed in the area. During the period of mating the two otters dived and emerged from their food gathering dives simultaneously. Because the male followed the female closely, the duration of her ives appeared to determine the duration of his. The mean duration f food dives was 65 seconds and the extremes were 20 and 95 econds. The majority of the dives (69 percent) lasted between 0 and 80 seconds (fig. 31).

In generalizing on the duration of food dives in the usual foraging depths, between 10 and 25 m., it may be said that the adult emale usually stays beneath the surface for about 1 minute and e adult male for about 1½ minutes.

The number of dives in a feeding period varies. In 9 hours and minutes when records were kept the mated pair spent 4 hours nd 45 minutes in feeding activity, making 87 dives in water aproximately 23 m. deep. Nikolaev and Skalkin (1963) report obervations of 63 dives in 1 hour and 18 dives in 12 minutes. Preumably these data were obtained from animals feeding in shallow ater.

uration of escape dives

The sea otter, however, is capable of dives of long duration. This as demonstrated when we pursued a female otter for 50 minutes n 10 July 1960 in the Bering Sea off Unimak Island. During the hase she made 13 dives averaging 120 seconds beneath the sur-



IGURE 31.—Duration of 87 timed food dives made by a mated pair of otters. The water depth was 23 m. The male followed the female closely, both in submerging and emerging.

face. The longest dive lasted for 250 seconds (4.2 minutes) an the shortest 30 seconds. The last timed dive of 205 second indicated that the animal had not become exhausted and w abandoned the chase as futile. Barabash-Nikiforov (1947) say that "the longest time that the sea otter can submerge is not mor than 6 minutes." My conclusion is that the maximum duration o a dive is probably less than 6 minutes.

Depth of diving and distance from shore

The maximum depth to which a sea otter may descend to gathe benthic food organisms is not definitely known. Consideration o the historical record along with modern observations and data however, indicate certain tentative conclusions.

The greatest diving depth I find in the historical record i quoted from Chase Littlejohn, a sea otter hunter of the 19t century. He said "There is a [place] . . . about 50 fathoms dee where they go to the depth of the water to feed" (Hall, 1945) Other otter hunters indicate lesser diving depths. Snow (1910 p. 281) stated that the sea otter appears to prefer to get its foo at depths of 10–25 fathoms.

Captain C. L. Hooper (1897) studied the sea otter and problem of conserving it in Alaska during the latter part of the 19t century. It was his conclusion that "banks of 30 fathoms of wate are its feeding grounds." Further, he concluded—

> that the principal parts of the present sea otter grounds are already withi the territorial waters of the United States. . . . suitable regulations by th United States Government, properly enforced, will furnish ample protectio for the sea otter, as not enough can be taken outside of these limits to en courage hunting to any extent.

This statement implies that otters seldom ventured to depth greater than those found relatively near shore.

Modern observations tend to confirm the early sea otter hunters information, except that in certain areas where shallow water i found far from land sea otters appear to find suitable feedin grounds beyond the 3-mile limit.

During seven seasons (April through August, 1957–63) A. C Hartt and B. F. Jones recorded all sea otters sighted beyond miles from shore. Their primary mission was offshore fisherie investigations during which their ships operated near variou Aleutian islands, in the passes between them, and as far as 20 miles from land in the North Pacific and Bering Sea.

Their observations of otters over deep water (table 10) are o interest, because in each case the otters were near areas wher shallower water was only a few miles distant. Also, the observations were in areas where strong tidal currents are prevalent. These could quickly move an otter sleeping on the surface several miles from a feeding area.

The observation of two otters 32 miles west of Kiska in the 55-mile wide pass between Buldir and Kiska Islands on 27 May 1959 (A. C. Hartt, letter, 1960) is of particular interest. Their presence there may be explained by the fact that they were near an underwater mountain ridge, Buldir Reef, which is about 20 nautical miles long and over a mile wide, and which offers considerable area having depths of from 17 to 30 fathoms.

The only available authentic record of an otter far from shore and away from passes between islands was recorded by G. T. Joynt (letter, 1957). While flying as a naval aviator in the Aleutians in the spring of 1943, Joynt saw an otter—

> a little over 50 miles due south of East Cape on Amchitka Island. On this particular day the open ocean was as smooth as a mill pond . . . This animal was observed at very close quarters and identity was certain because of the rarity of anything on the surface making a wake so far from land. I have often conjectured that this particular animal could have been a victim of an unintentional ride in a large free-floating kelp raft. Whenever sea otter were observed more than a half-mile from the nearest kelp patch it was usually a single animal and they were most frequently in the straits between two of the larger islands. On these occasions they were usually headed to one island or the other and not aimlessly swimming about.

Joynt was a trained biologist before becoming a naval aviator and gathered much useful information about sea otters in the Aleutians.

The large amount of time spent by the several observers (table 10) in offshore areas and the dearth of observations of sea otters at an appreciable distance from depths of 20 to 30 fathoms, demonstrate the tendency of otters to remain in shallow water.

On 10 July 1960, an adult female sea otter (KWK 60–19) was shot 9 nautical miles north of the Alaska Peninsula (55°20′ N. lat., 163°11′ W. long.) in water 20 fathoms (120 ft.) deep. The stomach contents (see Food and Feeding Behavior) consisted of benthic organisms. During aerial surveys of the area off the north coast of Unimak Island and south of Amak Island on 8 April 1962, the majority of 811 otters recorded were seen between 3 and 10 miles from shore in water from 10 to 25 fathoms deep. The majority were near or inside the 20-fathom curve. The 20-fathom curve where this large number of otters were seen ranged from 5 to 8 miles from the north shore of Unimak Island. I presumed that

TABLE 10.—*Observation of sea otters beyond 3 miles from shore in waters off Alaska*

Date	Number of otters	Nautical miles from land	Location	Water depth (fathoms)	Observer	Remarks
Spring 1943	1	50+	S. of E. Cape, Amchitka	2,000+	GTJ [1]	Aerial observation.
31 July 1957	Groups	6–7	S.W., Cape Sujaka Tanaga I.	200–300	J [2]	Floating kelp patches present.
15–19 Aug. 1957	do	ca. 8	S., Little Kiska I.	70–90	H [3]	Seen while en route from Kiska I. to fishing grounds.
27 May 1959	2	32	W. by N. of Sirius Point, Kiska I.	ca. 900	J	Floating kelp patches present; otters 25 yards from vessel.
11 May and 23 June 1960	Several	ca. 7	Sitkin Sound	40–60	H	Scattered otters seen en route Adak I. to Great Sitkin I.
10 July 1960	2	5	Bering Sea, S. of Amak I.	20–22	K	Specimen collected had food in stomach.
8 April 1962	811	3–10	Bering Sea, N. of Unimak I.	10–25	S & K [4]	Otters seen singly and in groups; feeding observed.
3 July 1963	2	6	S. by E. of Kagalaska Strait	ca. 100	J	Resting on surface.
9 July 1963	1	17	N. of Unimak I.	31	F [5]	Resting on surface.

[1] G. T. Joynt, Naval Aviator on patrol from Amchitka I.
[2] B. F. Jones, Fisheries Research Institute.
[3] A. C. Hartt, Fisheries Research Institute.
[4] D. L. Spencer and K. W. Kenyon, Bureau of Sport Fisheries and Wildlife.
[5] C. H. Fiscus, Bureau of Commercial Fisheries.

ght-colored objects seen on the chest of some of these animals ere food items.

Aerial observations of most of the Alaskan areas populated by a otters indicate that otters prefer to feed in depths of 5 to 15 thoms and that most of them, except off Unimak Island, are ithin about one-half mile of the shore. Weather conditions and ck of time prevented aerial examination of all shallow banks r from land where otters might be expected. On 3 May 1965, owever, Tahoma Reef (51°51′ N. lat., 175°50′ E. long.), Middle eef (52° N. lat., 176° E. long.), and Buldir Reef (52°10′ N. lat., 76°30′ E. long.), respectively, 30, 20, and 20 miles from the earest land (Buldir Island) and having considerable water areas om 3 to 20 fathoms in depth, were examined. Observation contions were excellent. We saw a number of birds and sea lions, rticularly in the kelp beds over Tahoma Reef, but sea otters ere absent.

Numerous observations of feeding otters near Amchitka Island, all seasons, indicate a preference there for depths of 5 to 20 thoms. Also, during rough winter weather otters are inclined search for food to a greater degree near shore. When the eather is mild they tend to move offshore to the vicinity of suberged reefs.

Several otters were observed over deep water and far from ore in the vicinity of drifting patches of floating kelp. This ggests that the otters could obtain food organisms that gathered the shelter of the kelp. It is known that pelagic fishes accumute under and around floating objects in the sea. That sea otters ight rarely adapt to pelagic feeding is intimated by Snow (1910, 280):

> n one occasion I found the stomach of an otter I killed some 8 or 10 miles fshore filled with the remains of a quantity of small fish with no signs of e remains of any crustaceans.

He does not, however, identify the area or state the depth of ater where this otter was taken. Marakov (1965, p. 214) also ports sea otters up to "15 miles from the coast in comparatively ep places." No authentic record, however, indicates that the sea ter is capable of adapting itself to the capture of pelagic organms where great depth prevents food gathering from the bottom.

In consideration of all the data available, it is my conclusion at sea otters feed in shallow water (1 to 15 fathoms deep) when fficient food is available there. When food resources are more oundant offshore and particularly in mild weather, they move to ed in depths of 20 or, rarely, 30 fathoms. Food dives to depths as great as 50 fathoms for food may be possible but otters are rarely seen in water as deep as 30 fathoms (180 ft.). No specimen is available to give positive evidence of food gathering at depths greater than 20 fathoms (120 ft.).

Our observations tend to confirm the conclusion of Barabash-Nikiforov (1947) that "the greatest depth to which it can go is 50 meters [164 ft.]"

WALKING AND RUNNING

Progression on land is similar but less agile than in other mustelids. The long, outer 5th digits of the hind flippers, which particularly aid progression when the otter swims on its back, hinder progress on land. Snow (1910, p. 275), however, exaggerated this hindrance when he wrote:

> The use, however, of the hind limbs is very limited, the toes appear to lack all muscular power, and the otter cannot place its hind-feet flat upon the ground; when it attempts to walk, the toes are doubled back under the soles.

As figure 32 illustrates, Snow's statement is not true. He probably received his impression from otters that were cornered

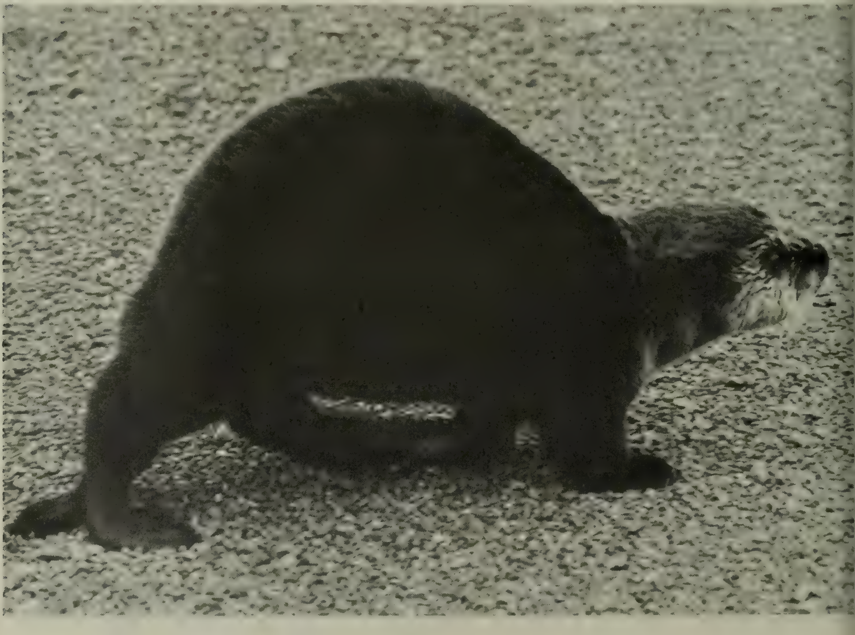


FIGURE 32.—Because the fifth digits of the hind flippers are long, the sea otter walks with a somewhat clumsy rolling gait. It moves somewhat more slowly than normal human walking speed. (KWK 62–10–29)

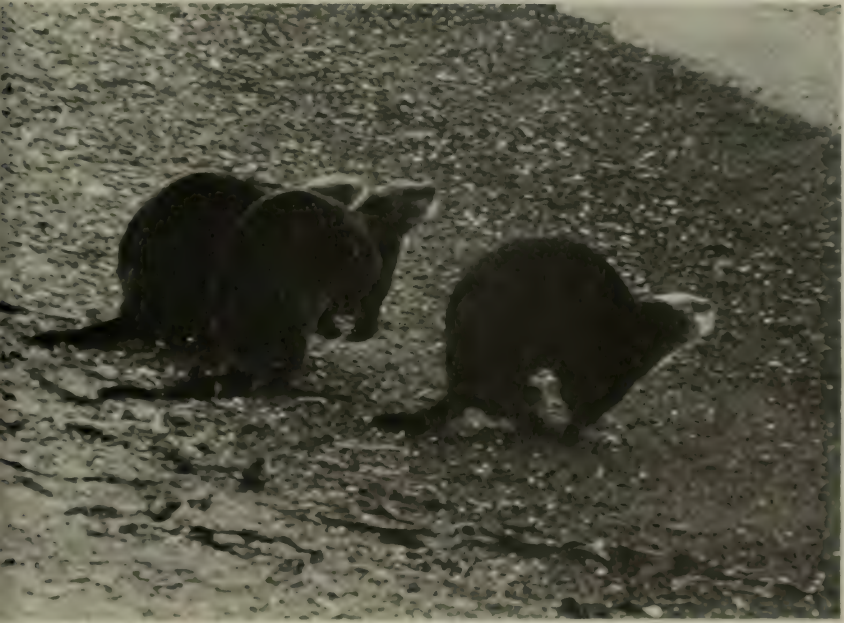
n land and trying frantically to escape the clubs of hunters. His mpression that the toes of the hind flipper were doubled back nder the foot when walking was so strong a conviction that he igured this unnatural position in the frontispiece of his book.

When the sea otter walks unhurriedly on land, it moves with a olling gait, raising one foot at a time and with the back arched fig. 32).

When animals some distance from the water are startled, they rch the back and bound or hop, moving both forefeet then both ind feet forward in rapid succession (fig. 33). Juveniles and oung adults are more agile than large, heavy adults. Some large nimals seem unable to raise their bodies from the ground and lide, with the help of the feet, across the beach on the belly.

Sleeping

The sea otter may sleep while floating on its back (fig. 34) or vhen hauled out on shore (fig. 84).



IGURE 33.—Adult sea otters, startled on a favorite hauling-out beach at Amchitka Island, bound toward the water in a typically mustelid manner. Speed of movement is somewhat less than the running speed of a normally agile man. (KWK 1027)

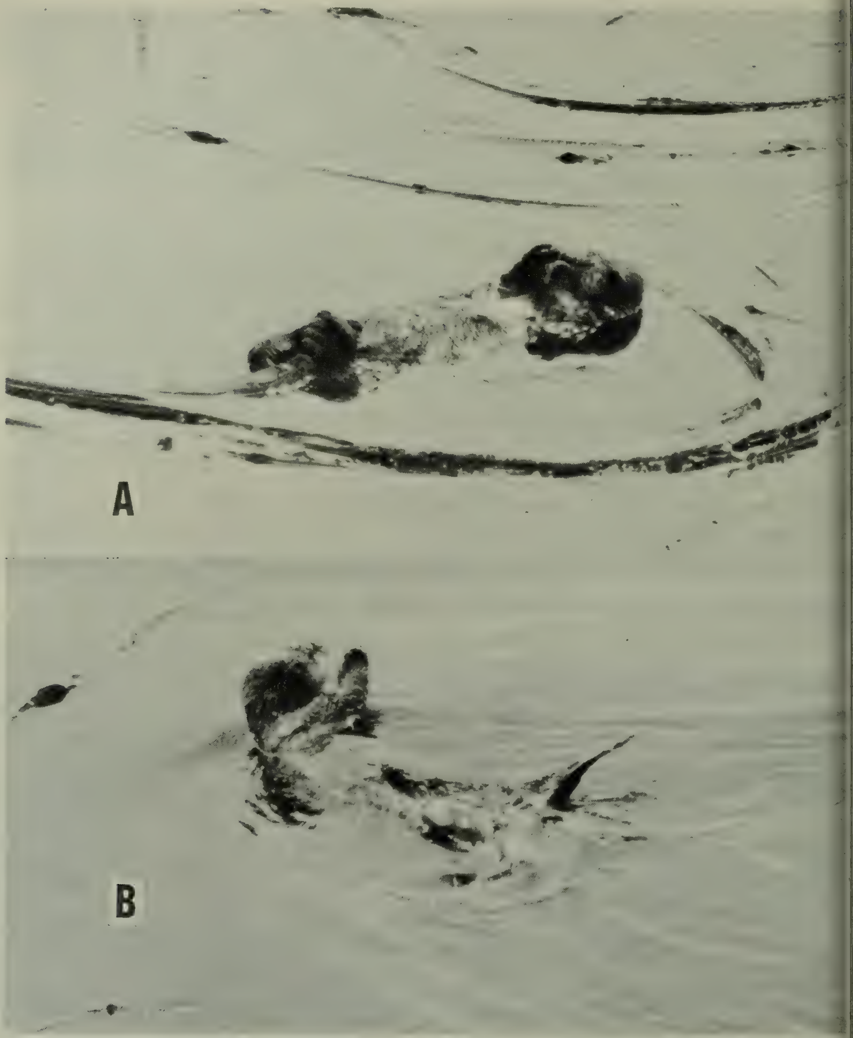


FIGURE 34.—*A*—Otters usually attempt to find a sheltered kelp bed before sleeping. After grooming is finished, the hind feet are folded on the abdomen. The forepaws may be placed over the eyes or against the side of the head or folded across the chest while sleeping. (KWK 56–4–4) *B*—This recently awakened otter is swimming languidly from its resting place while attempting to keep the head and forepaws dry. After awakening, otters appear reluctant to immerse the feet and head. (KWK 56–4–19)

Where kelp beds are available, the otters sleep in their protection. When surrounded by strands of kelp, the sleeping otter is protected from rough water and from movements by wind and water currents. Often, before going to sleep the otter uses its forepaws to pull one or several strands of kelp over its body; or it may make a shallow dive under the kelp strands, emerging with the strands in place over its body (fig. 35). In certain areas, for example off the north shore of Unimak Island, no kelp beds occur. In that area otters gather in large groups to sleep on the open sea (fig. 81).

Before going to sleep, otters scrub and groom their fur for about 5 to 15 minutes in the water. Then, if they haul out to sleep, the fur is preened and rubbed dry before sleeping.

On land the otter may sleep in many positions, from lying on the back as when sleeping in the water to stretching out flat on the belly or curling up nose-to-tail (fig. 84).

When otters awaken, they appear reluctant to get wet. If floating, they hold the feet, head, and tail aloft while rolling the body from side to side. Often they roll completely over, arching the back to avoid wetting the extremities. The head and forepaws are

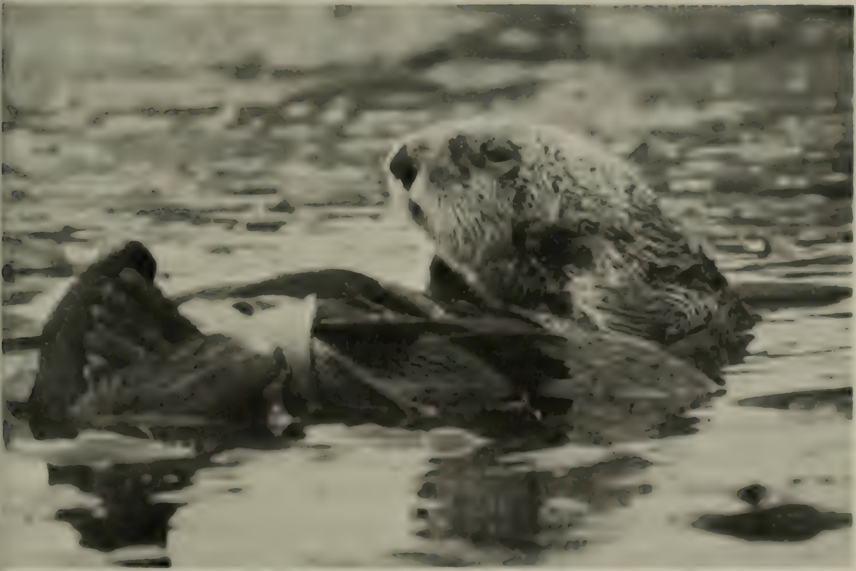


FIGURE 35.—A drowsy otter preens its cheeks with its forepaws before going to sleep. The hind flippers and tail protrude beyond strands of kelp (*Macrocystis*) that lie across its chest and belly and prevent movement by wind or current while the otter sleeps. (Photographed near Monterey, Calif., by Wm. F. Bryan)

usually the last to be immersed as the otter swims leisurely from its resting place (fig. 34).

When sleeping on land, an otter usually spends a variable time languidly preening its fur before entering the water. Then it may follow the procedure described above to delay wetting the feet, head, and tail.

Grooming

Pelage care is of primary importance to survival in the sea otter. Grooming is essential to maintain pelage cleanliness and waterproofness, and thus insulation against the chilly marine habitat. A blanket of air remains trapped among the dry underfur fibers which serves as insulation. A captive female sea otter spent 48 percent (about 7.5 hours) of the daylight hours grooming her fur and a wild female, observed for about 7½ hours, spent 11 percent of the time in grooming activity (table 64, Comparison of daily activities of wild and captive female sea otters, see In Captivity).

Grooming takes place either in the water or on land. Energetic grooming is done before rest periods and languid grooming (fig. 36) at intervals during a resting period and at the end of a rest period. Grooming may be divided into two primary phases, (1) washing the fur and (2) drying the fur.

Grooming is accomplished primarily by rubbing the fur with the palms of the forepaws, but the hind flippers may be rubbed together or against the fur of the abdomen and sides. The fur of all parts of the body is rubbed by the forepaws. To accomplish this and reach remote parts of the body, the otter may twist and squirm within its loose-fitting skin, so that areas of the mid-back can be reached. The flexible body may be rolled in a ball so that the forepaws reach beyond the root of the tail to the lower back (fig. 37). Also, loose skin of the sides and belly may be rolled over a foreleg while water is pressed from the pelage and removed with the tongue (fig. 38).

Water may be pressed from the fur by the palms of the forepaws (fig. 39). A fold of skin and fur may be pressed between the forepaws, squeezing water from the fur and the moisture removed with the tongue (fig. 40). The fur may be rubbed in a circular motion or by rapid strokes in many directions. The retractile claws (fig. 2) (see Physical Characteristics) are occasionally extended to aid in grooming but usually they remain retracted. Figure 41, illustrates a typical grooming posture.

GURE 36.—While dozing on the surface of her pool, a captive female sea tter languidly grooms the fur of her chest and sides. (KWK 61–10–34)

The fur is washed by rubbing submerged parts of the body with e forepaws and by rolling, head first, over and over at the surce. Rolling may be accomplished just prior to sleep on the water's rface. It smooths the fur and leaves a thin film of water in the ter pelage tips.

In the final stages of a grooming session the otter may rest belly wn at the surface, the head bent under the body while blowing r into the fur. Simultaneously the sides and belly are rubbed gorously with the forepaws (fig. 42). The fur may also be rated by a rapid churning motion of the forepaws, beating the ter to a foaming froth (fig. 43).

If the otter intends to rest on land, it swims to a point near the sired resting place. Here it goes through a 5- to 10-minute ooming routine before leaving the water. After hauling out, the ter energetically rubs and dries its fur (fig. 44).

In general, females tend to be more thorough than males in ooming their pelage. I sometimes saw males, but not females, ter hauling out, that failed to thoroughly groom and dry their r before sleeping.

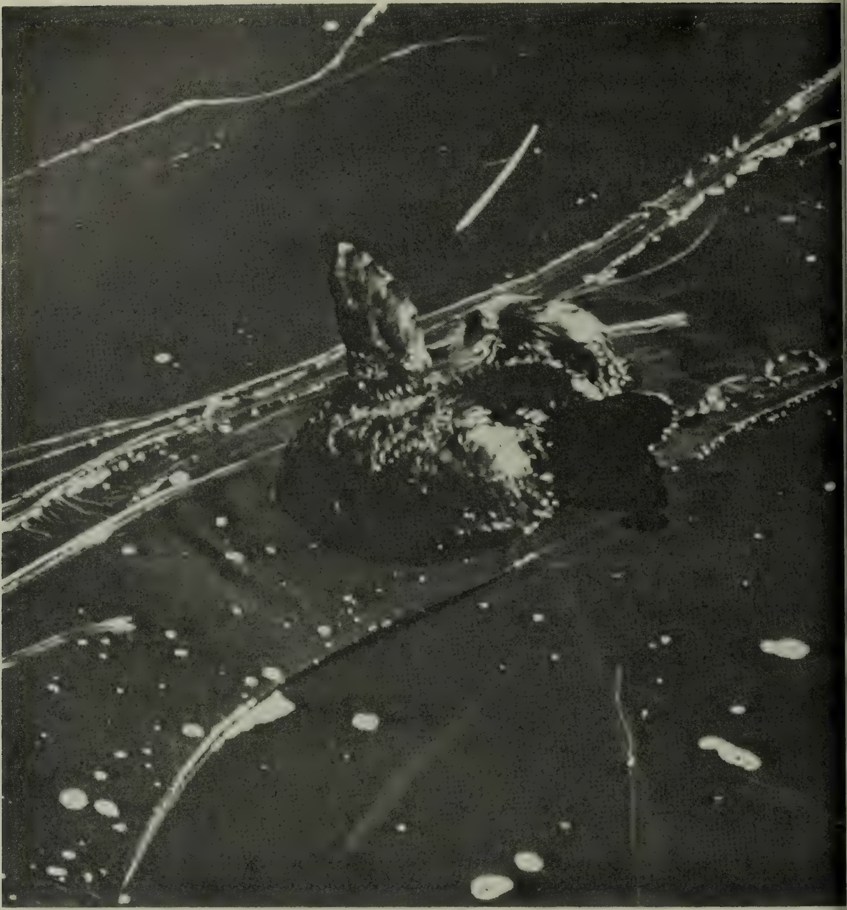


Figure 37.—The sea otter curls its long flexible body into a ball and reaches between the hind flippers to groom the tail and lower back. (KWK 1028).

Casual observers of grooming sea otters often misinterpret grooming for "scratching" and ask if sea otters have lice. They do not.

Voice

BABY CRY

This cry is uttered from birth until the large juvenile stage is passed. The pup cries when in distress or when it wants attention from its mother. The sound: a sharp, high pitched "waah-waah." This may be repeated constantly for long periods if the pup is

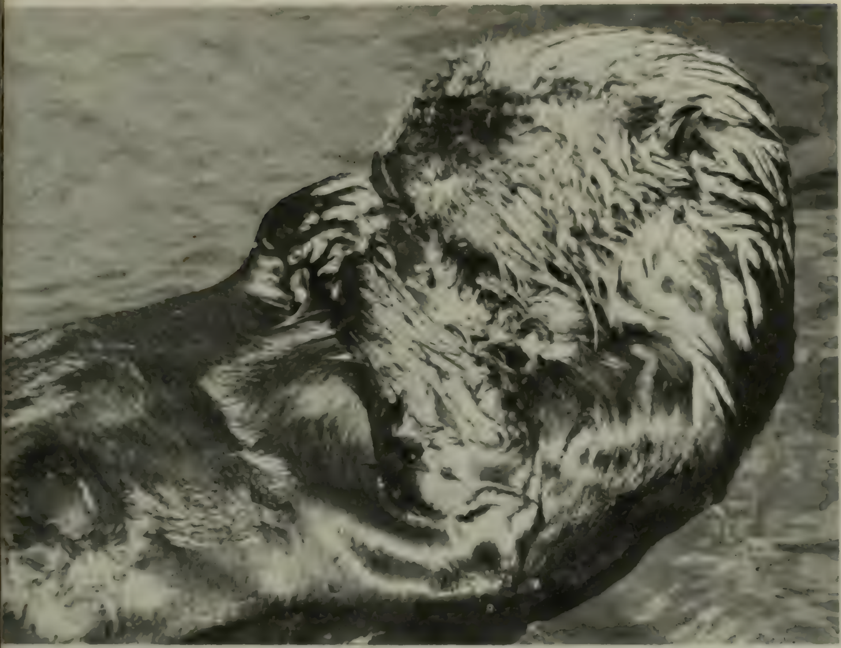


FIGURE 38.—Using its left paw, a grooming sea otter pulls the loose skin from its right side over the right foreleg in order to press water from the pelage and lick away the moisture. Moisture in the tips of the fur give the pelage a slick, wet appearance except on the head where dry, light-colored underfur is exposed by parting of the wet tips. (KWK 61–10–19)

separated from its mother and no tranquilizer is given. The sound resembles the cry of a young gull. The mouth is open wide when the cry is uttered.

SCREAM

This is uttered (1) when an adult is in severe distress—as when held in unsatisfactory captive conditions. Often it indicates that the animal is near death. It is not uttered when an animal is captured. (2) When a female has lost her young, as when the pup strays behind a rock, she screams repeatedly. This cry is the adult version of the baby cry. It is earsplitting at close quarters and can be heard at a distance of 1/4 to 1/2 mile in the wild and as far away as 200 meters when an animal is in a closed building. The mouth is open wide when the otter screams.

WHISTLE OR WHINE

This is uttered to denote frustration or mild distress. Captives

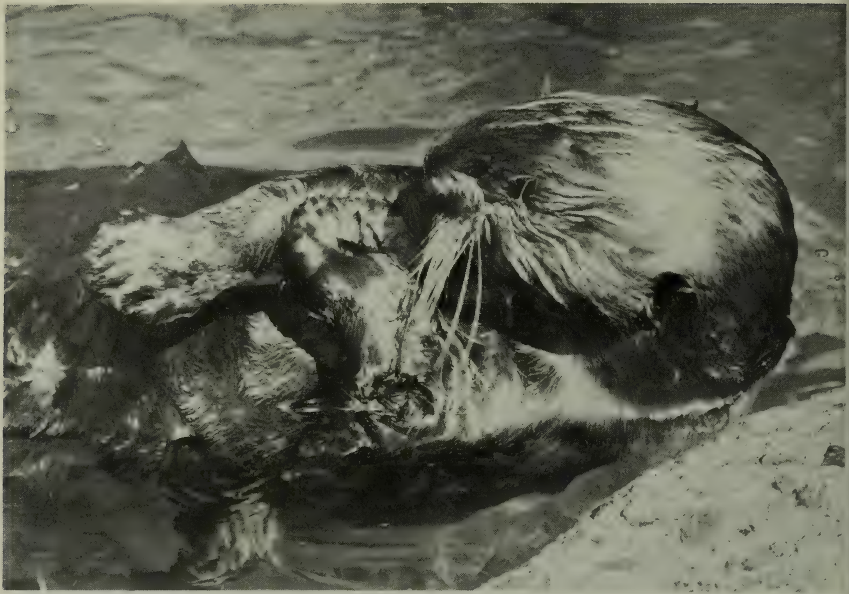


FIGURE 39.—While grooming, water is squeezed from the fur of the foreleg under pressure and by rubbing with the palm of the paw. (KWK 61–10–25)

whistle when the feeding schedule is delayed, and when they are carried on a truck or aircraft. The sound is uttered by adults and subadults primarily and to a lesser degree by juveniles. The whistle is loud enough to be heard to a distance of about 200 meters. It is a high pitched vocal sound that resembles a human whistle and is uttered with the mouth slightly open. "Wheeee wheeee" repeated often and of varying duration.

COOING

Females coo during premating and postmating behavior and also when grooming and fondling young. The coo appears to come from the throat and to denote satisfaction and contentment. Females coo while eating if the food is particularly pleasing. The mouth appears to be closed when it is uttered. Cooing can be heard up to a distance of about 15 to 30 m. on a quiet day. The sound "ku-ku-ku" may be continued for considerable periods either steadily or intermittently.

SNARL OR GROWL

This sound appears to originate deep in the throat and is uttered

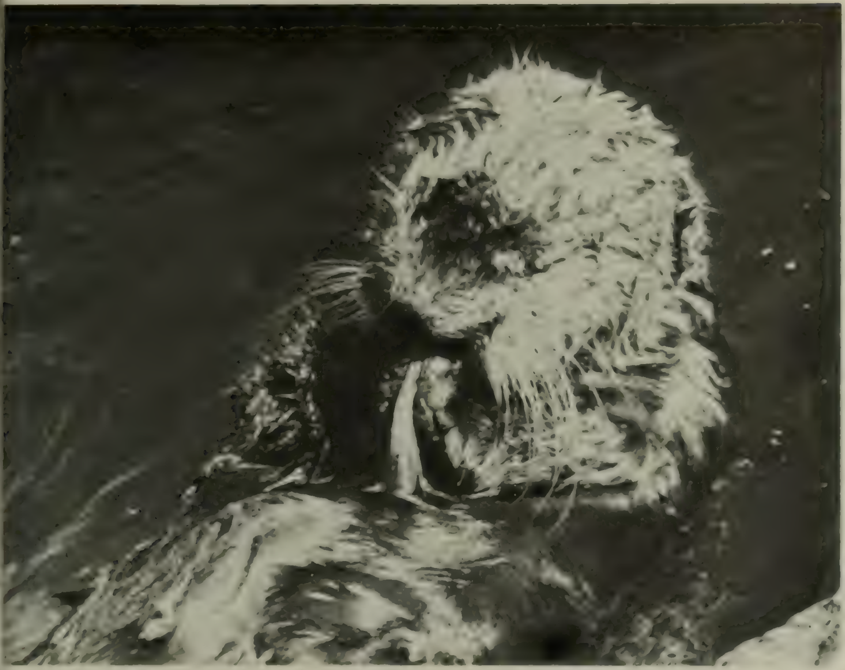


FIGURE 40.—While drying its pelage, a fold of skin is pressed between the palms of the forepaws. Water expelled from the fur is removed with the tongue. (KWK 61–10–10)

when a newly captured animal is attempting to escape from a net. The snarl or growl is audible only a few meters away.

HISSING (NONVOCAL)

Females hiss during capture, after capture, and before becoming tame. The sound is similar to a cat's hiss (as noted by Steller in his Journal) but more explosive and of short duration. The sound is characteristic primarily of females and juveniles. If a person appears unexpectedly near a caged otter the hiss may be uttered in the first moment of fright.

GRUNTING

When a hungry animal is eating voraciously it utters soft grunting sounds that appear to denote satisfaction. In the male this appears to be equivalent to the cooing of the female.

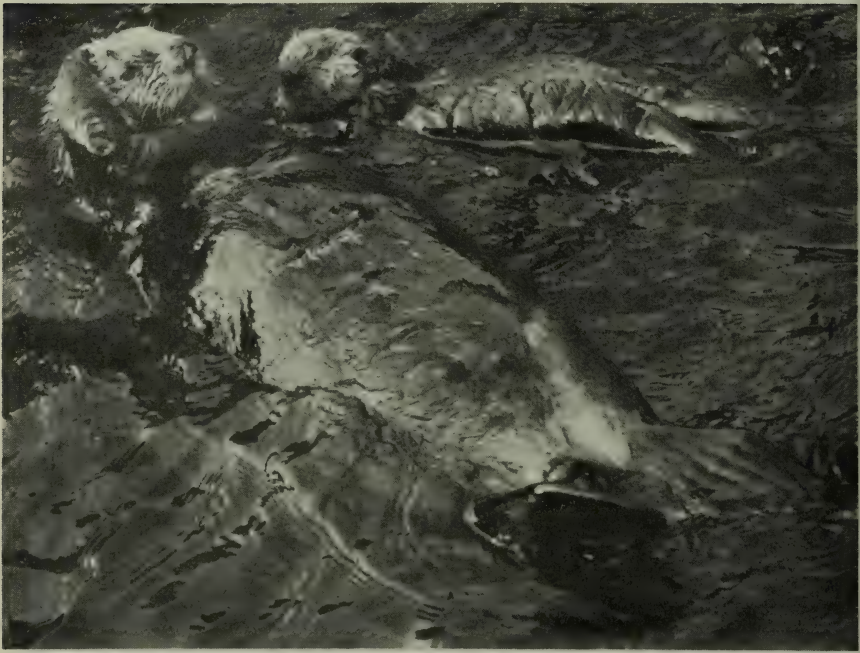


Figure 41.—A mother otter rubs the top of her head with one paw and her elbow with the other. Both paws are in constant motion during grooming. After grooming her own fur, the mother took her pup onto her chest and groomed and dried it before allowing it to nurse from her two abdominal nipples. (KWK 57–29–14)

BARK

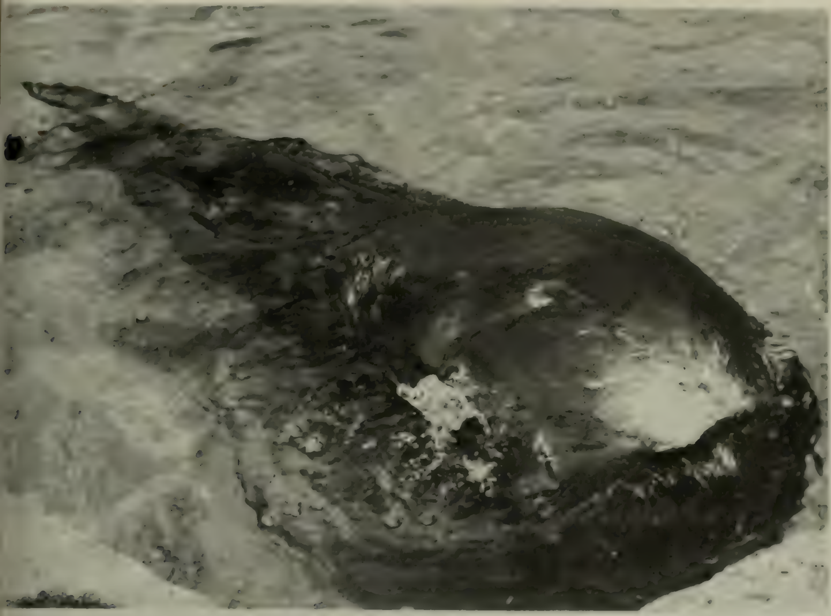
A yearling male during pool cleaning, while trapped in the empty pool and resenting thus being "cornered," uttered a staccato bark which trailed off into the whistle, apparently to denote frustration.

COUGHING, SNEEZING, AND YAWNING

Sounds as in other animals.

Handedness

During many hours of watching wild sea otters feeding, I noted that when the animals emerged from a food gathering dive the food items were carried to the surface under the left forelimb. Only if a large quantity of food was brought to the surface, i.e.,



GURE 42.—Near the end of a grooming period the sea otter rests belly down at the surface, bends the head to the belly, and vigorously blows air into the fur. At the same time it scrubs the fur on both sides with the forepaws. Note bubbles of exhaled air on water and splash caused by scrubbing paw. (KWK 61-10-26)

o much to be held under the left forelimb, did the otters place od under the right forelimb.

I have watched through calm, clear water while both captive d wild otters gathered food from the bottom. In all cases the ght paw appeared to be used dominantly in gathering food and acing it under the left forelimb. Both paws were used to pick e food from the bottom, then with the right paw the food was ushed under the left forelimb.

When food was eaten on the surface, the food item was retrieved om the "chest pouch" under the left forelimb by the right paw, ded by the left paw, then held between both paws while being ten. The teeth were usually employed to break the shells of nall sea urchins. Before a large hard-shelled green sea urchin as eaten, however, the top of the urchin was cradled in the left aw while pressure was exerted by the heel and sometimes the toes the right paw to crush the test around the oral opening of the rchin. The urchin was rotated against the left palm, so that the

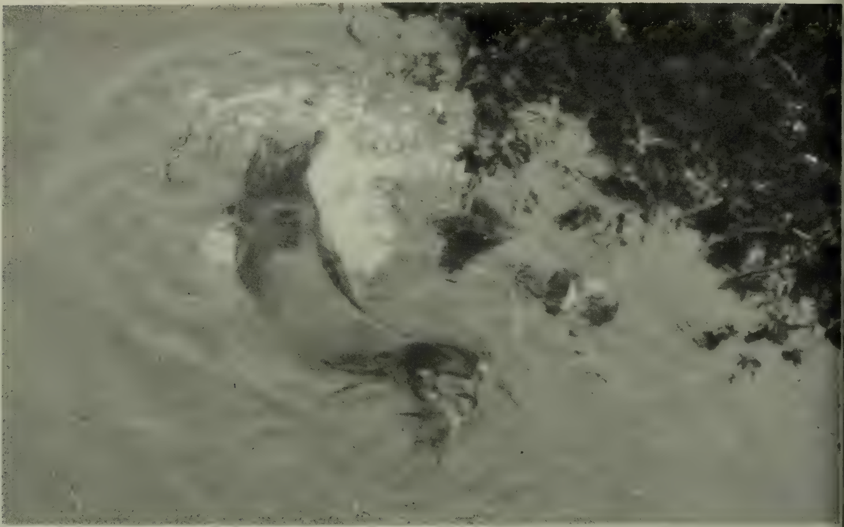


FIGURE 43.—During the grooming period, before hauling out, the sea otte may beat the water to a froth with the front legs, perhaps aerating the fu to some degree. (KWK 55–19–3)

test was broken completely around the oral orifice before the teet were employed to remove the broken shell.

From these observations I have concluded that the sea otter i right-handed. In hundreds of animals observed I have never see food items brought to the surface under the right forelimb unles the quantity was too great for the left limb to accommodate.

Handedness in other animals is variable. Warren (1953) dem onstrated that in the Rhesus monkey the right and left hands a used with about equal frequency. Lane (1946) indicated that bird of prey tend to be left-footed, and parrots (Friedman and Davi 1938) are similar. Pigeons, Fisher (1957) concluded, tended to b right-footed.

Further study under experimental conditions may reveal if se otters invariably exhibit right-handedness.

Tool-using

The use of a rock or hard-shelled mollusk held on the chest a an "anvil" for breaking the shell of a clam held in the forepaws discussed under Food and Feeding Behavior. Chest pounding wit the forepaws commonly occurs as an apparent expression of fru

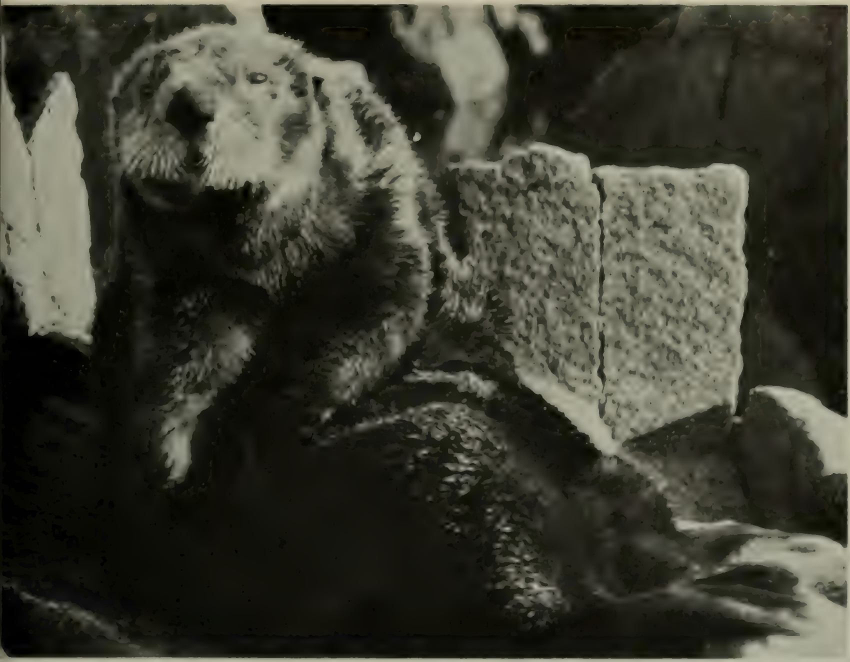


FIGURE 44.—After hauling out, the otter usually rests on its back while grooming and drying its fur before sleeping. (KWK 57–32–4)

tration, as when an otter has been robbed of its food by another otter. Perhaps the pounding of a hard-shelled mollusk against another originated because of frustration when the otter could not break, with its teeth, the shell of a food organism. At Amchitka, where the shells of mussels are crushed by the post-canine teeth, food pounding behavior is not observed. Where feeding was observed in Alaska, hard-shelled clams were not eaten and mussels *(Mytilus)* do not grow as large as those in California where they are commonly pounded against a hard object (Hall and Schaller, 1964).

When captive otters from Amchitka were presented with clams that could not be broken with the teeth or crushed between the paws, they broke them against a rock or another clam on the chest (fig. 45) or by pounding them on the cement edge of the pool (fig. 59). A female also pounded smelts (Osmeridae), and herring (Clupeidae) which she did not particularly relish (fig. 46), and she pounded a rock on the edge of her pool. Thus, animals that came from an area where food organisms were not observed to be broken by pounding, used this technique when frustrated by

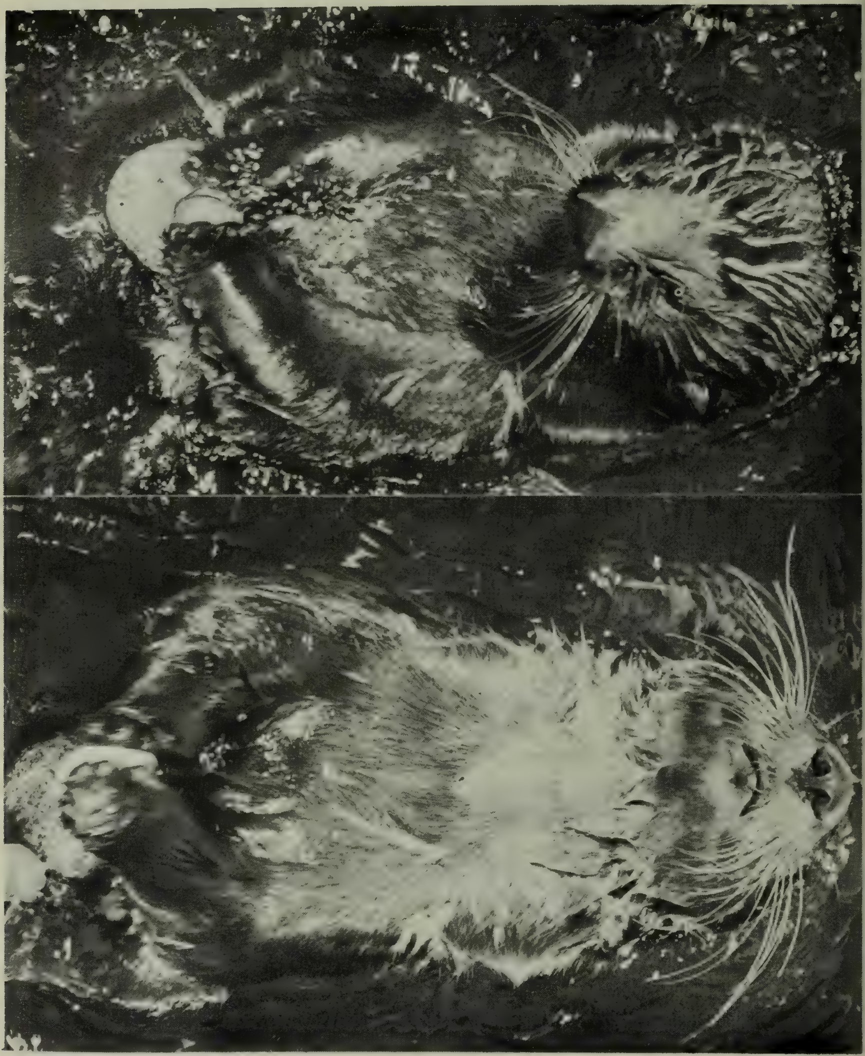


FIGURE 45.—A captive adult male sea otter from Amchitka Island pounds a clam, held between his forepaws, against a rock resting on his chest. Usually the head is held erect (above) but not infrequently it is extended during food pounding behavior (below). (KWK 67–15–7 above, 67–14–30 below)

hard-shelled organisms or by fish they did not care for. Also (Kenyon, 1959), a sea otter pounded a drain cover with a rock when the cover frustrated a desire to explore the drain. I consider the sea otter's tool-using behavior, as derived from chest-pounding,

GURE 46.—A captive otter pounded herring (*Clupea*) against the cement edge of her pool. The otter did not particularly relish this species as food, and the pounding behavior appeared to denote frustration when more appetizing food was not available. The irregular surface of the pool edge shown was produced when the otter pounded this area with a rock, cracking away the finishing layer. Rock pounding behavior appeared to express frustration when food was not available in the pool. (KWK 61-10-27)

ustration behavior. Also, I agree with the statement of Hall 1965) that the pounding behavior in the sea otter is—

> t a behavioural adaptation that has no special relevance to the evolution of e sort of intelligent, anticipatory skills which are most highly developed man and which he uses for the manufacture of a standard set of tools to kept in store and used on different occasions for various purposes.

Thus, tool-using behavior in the sea otter might be likened to e use of gravity by gulls and ravens. These birds commonly

break the shells of clams and mussels by carrying them aloft an
letting them fall on a rocky beach.

Defense and Escape

ON LAND

When a sea otter on shore finds itself cornered and cut off fro
escape to the sea it stiffens, faces the approaching intruder, an
begins to rear backward (fig. 47). If the intruder continues t
approach, the otter flops onto its back (fig. 48). If it is approache
more closely, it may hiss and the stiffened forelegs are extende
(fig. 49). The animal may attempt to bite any object extende
toward it, while using the forepaws to push it away. I have neve
seen a cornered animal attempt aggressively to attack huma
intruders. Defense and escape are the only reactions.

IN THE WATER

When a sea otter is surprised at close quarters by an intrude
it first rises high in the water. It faces the intruder and extend

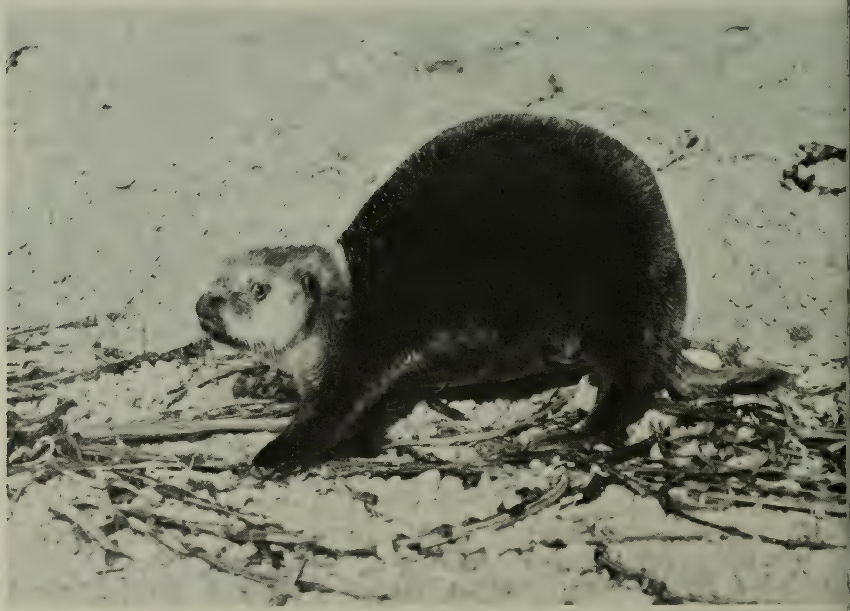
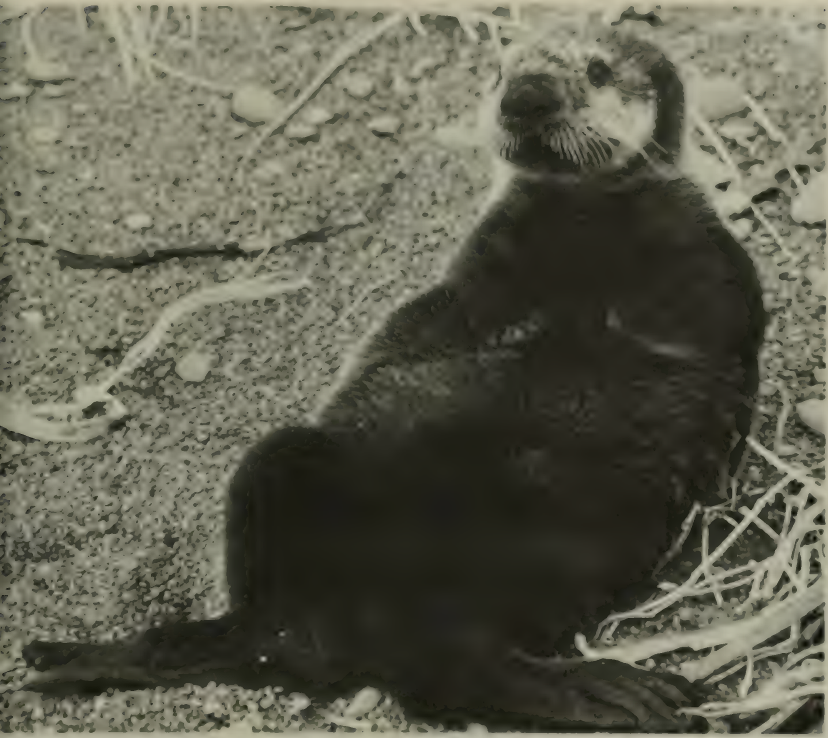


FIGURE 47.—A juvenile sea otter, cornered on an Amchitka beach, prepare
to rear backwards to assume the defensive posture illustrated in figur
48. (KWK 62-10-10)



GURE 48.—In the defensive position a sea otter lies on its back, faces the source of danger, and is alert to repel an attack. If an advance is made to touch an animal in this position, it attempts to bite and to push the adversary with its forepaws. The forepaws may also be used to aid in bringing the teeth into contact with the adversary. (KWK 62–10–26)

s forelegs, stiffly, palms of the forepaws outward toward the truder. It then submerges vertically, pushing the forelegs above e head. It sinks backward beneath the surface, rather than unging forward as in a normal dive.

Maternal and Filial Behavior

URATION OF DEPENDENT PERIOD

The place of birth is discussed under "Reproduction in the emale." In her paper on the "Early life of a sea otter pup," isher (1940a) described many aspects of the behavior of mother nd pup. Other writers have remarked on the unusual care of the other for her young.

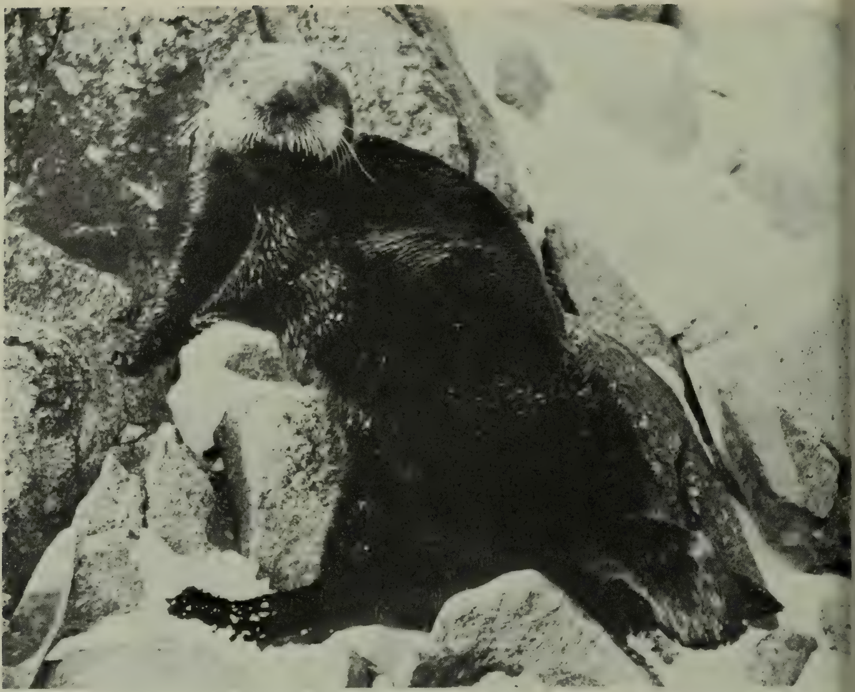


FIGURE 49.—When closely approached, a cornered sea otter hisses, extends its stiffened forelegs, and rears backwards as far as possible. No aggressive behavior is displayed. (KWK 59–8–6)

The period of dependence is unusually long. This was not ascertained directly from known individuals, but indirectly through various observations at Amchitka. Female reproductive tracts from there indicate that the majority of young are born from early spring to summer (see Reproduction in the Female). In the fall and early winter, large juveniles are numerous. During the late winter and early spring period of high mortality (March to May), most of the juveniles that die weigh 20 to 30 lb. (9 to 14 kg.). At the end of the annual "die-off" few large juveniles can be found alive. Observations during this period of juveniles crying and swimming about, apparently in search of their mothers, plus data compiled under "Mortality Factors" and "Home Range" indicate that most of these young animals are abandoned by mothers in the period of stress caused by storms and depleted food resources.

It is assumed that this group of young, most of which were dead by May, were the young that were born in the previous spring and early summer, in which case they would be 10 to 12 months old at time of death. Young that were born in the fall and winter were small (5 to 10 lb., 2.3 to 4.5 kg.) during the period of stress, and being less a burden to their mothers were cared for during this season. These were the young that survived to augment the population.

During summer, some dependent juveniles were larger than those that were deserted and died during the season of stress, indicating that they were probably more than a year old. Thus, I believe that the period of dependence of the young is normally at least a year and probably somewhat longer. Young somewhat less than 1 year old and in the 15 to 25 lb. (7 to 11 kg.) group do not usually survive in the wild if premanently separated from their mothers, particularly if separation occurs shortly before or during the season of stress.

At birth the pup is helpless and remains so for several weeks. When the mother dives for food the pup is left floating on its back at the surface, where it usually sleeps. If the pup awakens while its mother is diving, it may squirm and move its hind flippers about in an uncoordinated way. A very young pup appears unable to roll over onto its belly, which the pup apparently attempts to do by twisting the forward half of its body (fig. 50).

The ages of pups in the wild are estimated on the assumption that during the first year of life a pup grows at a nearly constant rate from about 5 lb. (2.3 kg.) at birth to about 30 lb. (14 kg.) when mother and young may separate. The sizes of pups are estimated by visually comparing pups in the wild with animals of similar body size that are weighed. On this basis, it is estimated that the pup remains nearly helpless during the first month, although it is able to crawl weakly for a meter or so on land (fig. 51) and swim weakly in an uncoordinated fashion.

SOLICITUDE

Much has been written of the solicitude of the mother sea otter for her young. Snow (1910, p. 142) noted the reluctance of a mother to abandon her pup.

> For two hours we chased this otter, pursuing her between the rocks. The pup had been killed during the first hour, but she was holding it as firmly as ever, until a shot, striking one of her paws, made her drop it; and in trying to regain it she was once more wounded. Again and again she made the attempt, all the time giving utterance to the most plaintive and sorrowful cries . . .

After retrieving the pup, which the mother was unable to pick

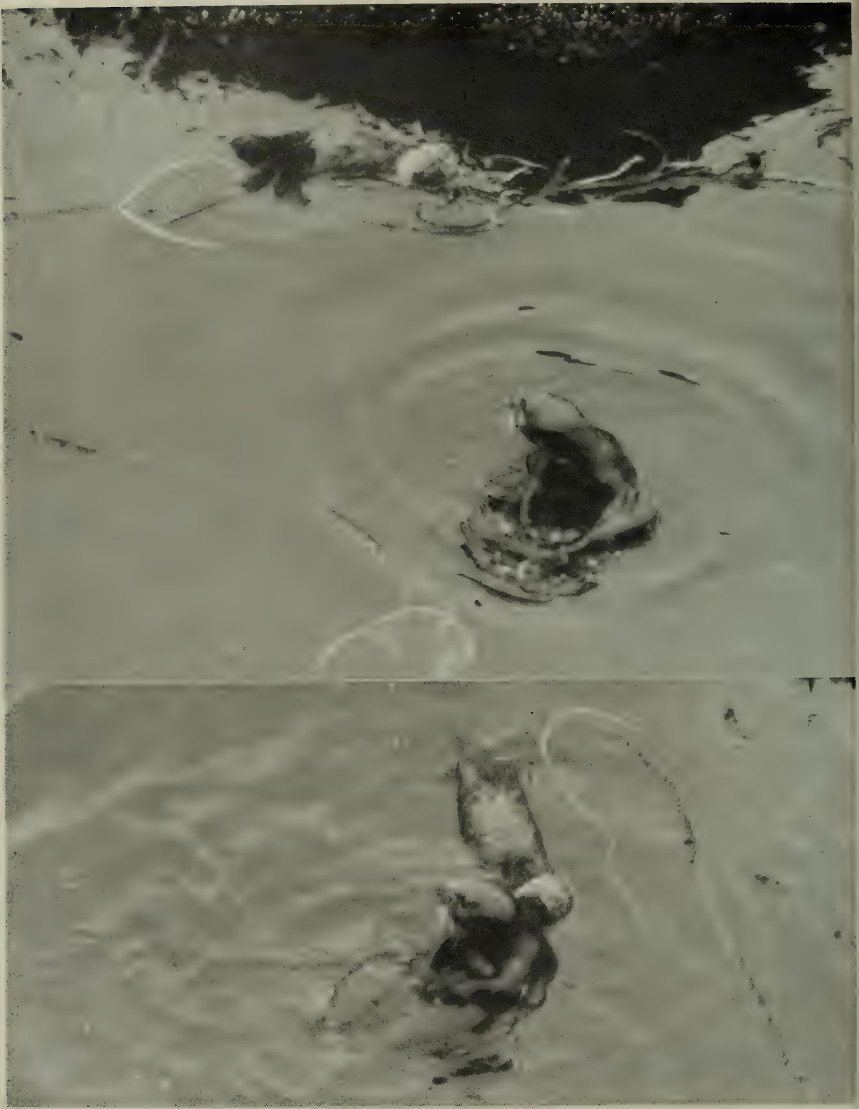


FIGURE 50.—(Above) After a feeding period and before taking her 3- to 4-week-old pup ashore, the mother sea otter scrubs and grooms her fur with her forepaws. The pup at this stage is unable to swim. By aimless strokes of its hind flippers it may move about in a circle or attempt to roll over (as shown here) to grasp a kelp strand. While she washes and grooms, the mother seldom moves more than a meter from her pup and usually stays close beside it (below). She watches it constantly. (KWK 55–19–7 and 9; 11 September 1955)

IGURE 51.—A captive mother sea otter leads her 3- to 4-week-old pup from the water. This appeared to be a "walking lesson." At other times the mother carried her almost helpless pup from the water in her mouth. (KWK 57–27–8)

p because of her wounds, the hunters started to return to their hip and later that same night, Snow wrote:

> e had traveled some distance, when all at once, right under our stern, we eard the most unearthly crying imaginable; . . . another cry alongside owed us the dark form of the otter we had been chasing. It was now llowing the boat, lamenting the loss of her offspring.

The possessiveness of the mother sea otter is evident from birth ntil the young one is one-half to nearly two-thirds the mother's ize (fig. 52). Virtually the only time that the mother is apart from er pup is while she is diving for food, while preening, or when wimming beside the pup. On one occasion I watched a mother ith a juvenile nearly as large as she. They rested together on a ock until the energetic young one began to explore nearby. When t went to the water as if to depart, the mother rolled forward, rasped the juvenile's hind flipper in her teeth, and did not release t until the young one turned and resumed its position near her.

Many observations of mothers and young at Amchitka indicate hat the ties between them may be strong but that the strength of he mother-young bond varies with each individual.

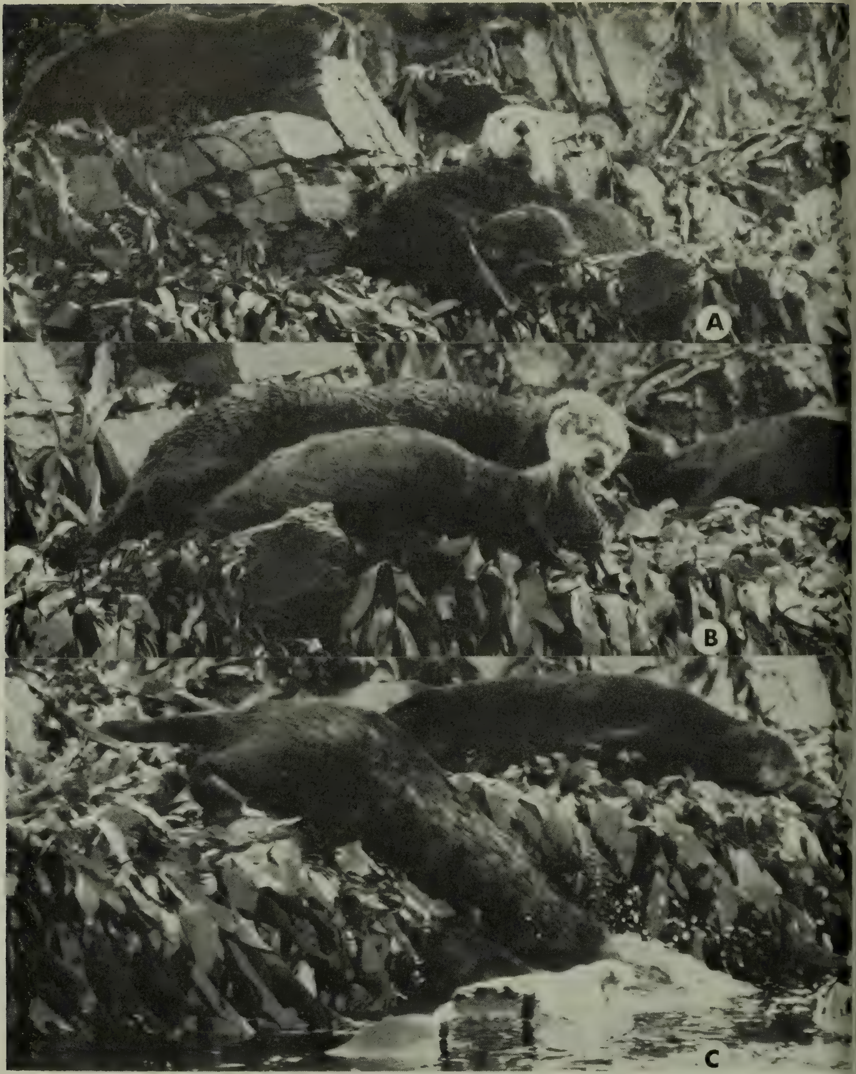


FIGURE 52.—The mother is solicitous of her young for a long period. *A*—A large juvenile, probably weighing about 20 lb. (9 kg.) and about 8 months old, nurses while its mother preens its fur. *B*—Alarmed by the photographer, the mother grasps her young one by the side of the head and, *C*, plunges with it into the water. (KWK 62–19–31, 32, and 37)

On 6 May 1959, a juvenile (about 16 lb., 7 kg., in weight), sleeping beside its mother on rocks near deep water, was captured in a dip net after the mother awoke and escaped. Three times within the next 5 minutes, while a metal tag was being attached to the pup's flipper, the mother partially emerged from the water, grasped the net in her teeth, and attempted to drag it and her pup away.

A captive mother and her very young pup were held in a high-walled enclosure. During the windy night of 28 November 1957, the enclosure door blew open and the mother escaped. When I arrived soon after sunrise, I found her swimming about in the surf near shore and shrieking repeatedly. On entering the enclosure I found her pup still sleeping soundly. When I awoke the pup and carried it outside, it began to cry in answer to its mother's calls. In response, she rushed ashore and was easily recaptured.

The fearlessness of a mother in coming to the aid of her pup is often less strongly expressed than in the above two examples. During tagging operations we frequently netted mothers with large young. Usually when the mother was liberated in advance of her pup, she swam 50 to 100 m. from shore where she uttered repeated shrieks until joined by her pup.

Whenever a mother with a small helpless pup was captured, we attempted to return the pup to its mother as she was liberated. Usually, the mother grasped the side of the pup's head in her teeth and swam rapidly away. Occasionally, however, the frightened mother failed to take her young one. On 5 April 1959 a mother and her pup were captured and tagged on an Amchitka beach. In my field notes I recorded:

> The mother of the newborn pup (Tag. No. EL 12938) was released close to her helpless pup so that she brushed over it as she ran to the water, but she failed to pick it up. This was at 1445. I watched from a hiding place until 1720 (2 hrs. and 35 min.). During this time, the mother swam about in a 200 m. radius, screaming frequently. She made 13 approaches to the beach, then swam out among the reefs, and continued to utter loud screams. On the 4th and 8th trips toward the beach, she approached to within 3-4 m. of the pup, then became frightened and swam out. Three other otters hauled up on the beach near the pup but the mother was not reassured and would not come out onto the beach. When I left, because of cold, she was still in the vicinity screaming.

Because of the possible loss of the young during tagging operations, the capture of mothers with helpless pups was discontinued.

A young otter may also demonstrate concern for its mother, as suggested by my field notes (27 February 1962):

> A mother and her 15-pound male pup were captured as they slept side-by-side on the beach today at St. Makarius Pt. W. (Amchitka Island). They were caught in separate nets. The pup was tagged first and released. Instead of heading for the water he ran to his struggling mother, put his forepaws on her side and began tearing at the net with his teeth and tried to climb up on her side. He had to be dragged away while a tag was placed on the mother's

> flipper. As soon as she was released, he rushed to her side and then followed her to the water. After a dive of about 50 meters, the two came up. The pup immediately clasped his mother about the neck and she pulled him toward her with her forepaws. This was a healthy, energetic pup.

Fright during capture may temporarily upset the normal behavior of a pup towards its mother (Field notes, 27 March 1962):

> Today we captured in the same net a mother with a large pup as they slept beside each other on the cobble beach at Rifle Range Point (Amchitka Island). After the net was placed over them, they both began to struggle violently and the pup attacked the mother, biting her wherever it could. The mother paid little attention to the pup except that when its head came near hers she attempted to grasp the back of its neck in her teeth—as if to carry it off with her. We removed the pup from the net and tagged it. It was released about 2 feet from the struggling, still netted mother. It rushed to her and bit her on the side in several places. The mother ignored the bites and struggled on with the net. After tagging, the mother was released. As she ran to the water, the pup followed her. The mother swam rapidly for about 100 m., then stopped and the pup surfaced beside her and put its forepaws around her neck while both looked back at us before swimming out together—their fright apparently forgotten.

ATTENTION TO DEAD YOUNG

Mothers were occasionally seen carrying dead pups. I watched a mother carrying a dead, watersoaked pup while she emerged from the water and rested on kelp-covered rocks. For nearly an hour she licked the water from the pup's pelage and groomed its fur with her forepaws. When it was fluffy and dry, she went to sleep with it on her chest. How long a mother will attend a dead pup is not known but one was observed in which patches of skin and hair were slipping from the body, indicating that it had been dead for several days. A dead pup was removed from beside a sleeping captive mother after she had carried the carcass with her for 31 hours. On several occasions we attempted to take dead young from mothers seen resting on tidal rocks. Mother otters, however, are wary and in each instance, the mother escaped, carrying the carcass with her.

Although mother otters carry their pups beneath the surface during escape dives, they normally leave the young one floating on the surface when they dive for food. Dead pups, however, were carried by the mother while food diving. Unanswered questions are: Did the pup die because the mother carried it while diving for food? or did the mother carry it to avoid its loss because the fur became watersoaked causing it to sink after the pup died?

IOVING YOUNG

While swimming on her back, the mother sea otter carries her up clasped between her forepaws (fig. 53). After a feeding or reening period, when the pup floats near its mother, she may rasp the pup with her forepaws and lift it onto her chest or she ay roll on her side, clasp the pup to her chest and then roll again nto her back. If a mother with a pup is frightened or pursued, he holds the pup tightly with her forelegs and grasps the side of s head in her teeth as she turns to dive. Small young may drown uring escape dives if the mother must dive repeatedly at short tervals (see Diving).

On land the mother otter grasps the side or back of the pup's ead in her teeth and drags it. The pup is limp and relaxed, as if ead, while it is being dragged. Large juveniles usually walk bede the mother when they haul out but if alarmed, the mother rasps the youngster by the head and drags it. Although a juve-

IGURE 53.—The mother sea otter carries her pup high on her chest, clasped by both front paws. White scar tissue was seen frequently on the noses of adult females but rarely on juveniles or adult males. It is presumed that these scars are inflicted by the male during mating when the nose of the female is grasped by the male's teeth, usually causing it to bleed. (KWK 57-29-27)

nile weighing 15 to 20 lb. (7 to 9 kg.) may be at least as agile on land as its mother, it relaxes completely when grasped by the mother and allows itself to be dragged, even over rough terrain, making no effort to assist in its own progress (fig. 54).

NURSING

The mother sea otter nurses her pup from two abdominal nipples, usually while floating on her back. Nursing may also take place on land (fig. 55). When the pup is small it usually rests on the mother's chest and abdomen while nursing, both on land or while the mother is floating. If the pup becomes hungry and cries while its mother is feeding, she grasps it around the chest with her forepaws and rolls it onto her chest, then turns it around, pushing it headforemost toward her abdominal nipples, allowing it to nurse.

As the pup grows larger it nurses while floating belly down, its body at right angles to that of its mother. Nursing periods are short, lasting 2 to 5 minutes. The pup kneads its mother's abdomen while nursing. It was difficult to time the duration of the nursing period because pups often fell asleep within 5 minutes and the actual duration of the nursing period was in doubt.

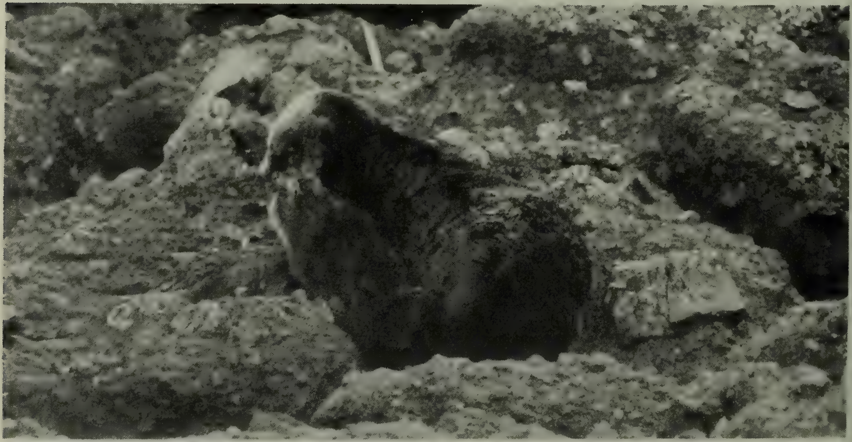
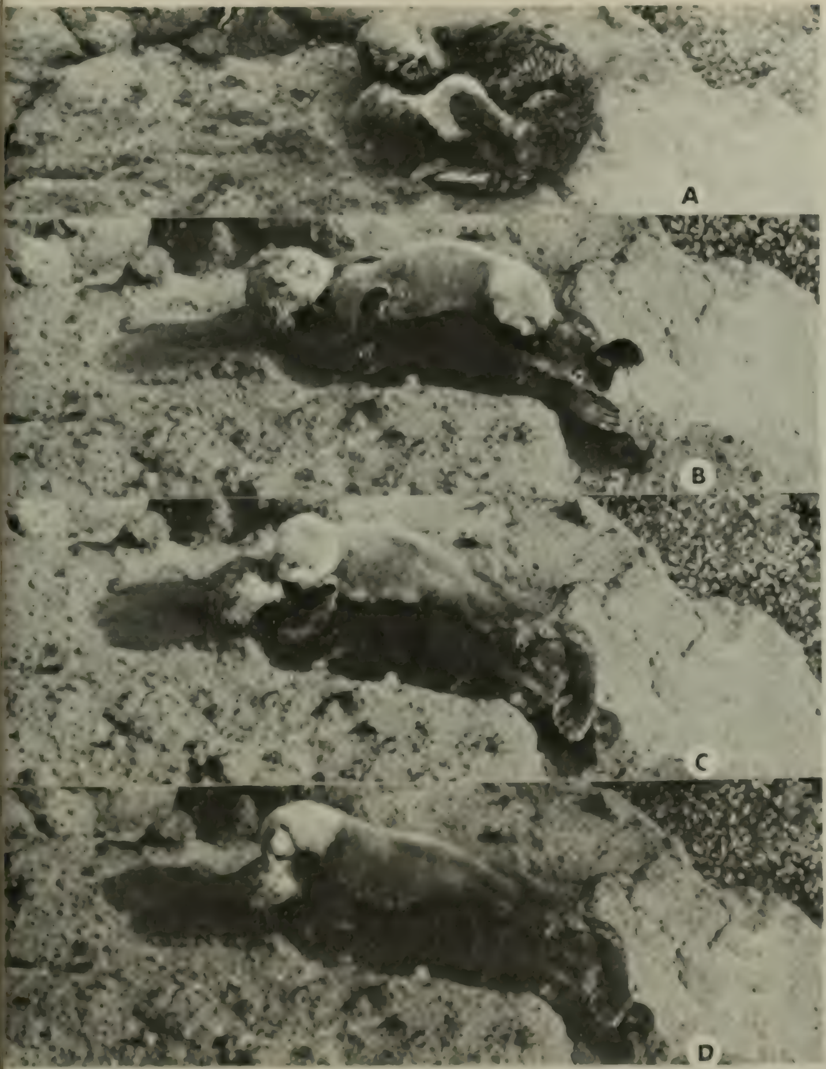


FIGURE 54.—This mother sea otter and her large juvenile (estimated weight 20-22 lb., 9-10 kg.) were surprised on land. Although the pup was capable of running at least as fast as the mother, she grasped the side of its head in her teeth and dragged it. On the rough terrain the pup bounced and caught in crevices but it remained relaxed and limp. When the two reached the water the pup was allowed to swim free of its mother's grasp. (KWK 62–17–37)



GURE 55.—*A*—After dragging her pup onto a rock, a mother sea otter preens and dries her fur while she supports the head of her nursing pup with a hind flipper. *B*—After drying her fur, the mother takes her pup on her chest and while she preens its fur with her forepaws she allows it to nurse from one of her two abdominal nipples. *C*—After the pup has nursed for 3 to 5 minutes the mother turns it around and fondles and plays with it. *D*—Mother and pup sleep, their fur dry and fluffy. This pup is probably a month to 6 weeks old. Its natal coat, particularly the long yellow guard hairs have grown considerably since birth. During the approximately 30-minute period when this sequence was taken, the mother frequently made soft chuckling or cooing sounds. (KWK 55-20-36, 55-934, 936, and 938)

Large juveniles often attempt to nurse. When the mother is reluctant, she rolls over. If the young otter is persistent and clasps her firmly with the forelegs, she may roll on a horizontal axis rapidly through 5 to 10 rotations, which usually dislodges it.

SWIMMING

At an early age, while the pup is still nearly helpless, the mother occasionally lifts it from her chest, places it in the water, then swims slowly away from it. The pup swims belly down paddling clumsily with all four feet. During these early swimming sessions, the pup frequently cries. The mother may remain just beyond the pup's reach for 50 m. or more before she allows it to overtake her when she again rolls or lifts it onto her chest. By the time the pup reaches an estimated age of 2 to 3 months, swimming ability is improved and it appears more at ease, crying less when swimming. When the mother swims near the pup it does not attempt frantically to reach her but swims quietly beside her (fig. 56). At this stage the pup apparently has not learned to swim on its back. Swimming on the back appears to develop slowly. While the mother is resting the pup often plays, swimming and making shallow dives near her. During these periods the pup appears to develop the ability to swim on its back.

DIVING AND FOOD GATHERING

After a pup learns to swim, it attempts to dive. Its first dives barely take it beneath the surface and considerable effort over a period of time is required to overcome the buoyancy of its air-filled fur. When the pup finally learns to reach the bottom in shallow water it brings up starfishes, bits of kelp, and pebbles. Seldom does it obtain edible items. Even after the pup is nearly a year old and about three-quarters as large as its mother, and may obtain much of its own food by diving, it continues to depend on its mother to satisfy its food needs.

From the time of birth the young otter is able to consume solid food which its mother gives to it. In the early weeks of life, however, stomach examinations indicate that milk predominates in its diet. After the pup is a month or two old it frequently pesters its mother for food. When she emerges from a food dive, the pup climbs onto her chest to beg for and receive part of the food she has brought to the surface (fig. 57). Large juveniles, able to dive well but unable to satisfy their food needs, may snatch food forcibly from the tolerant mother while she is floating on the surface and eating.

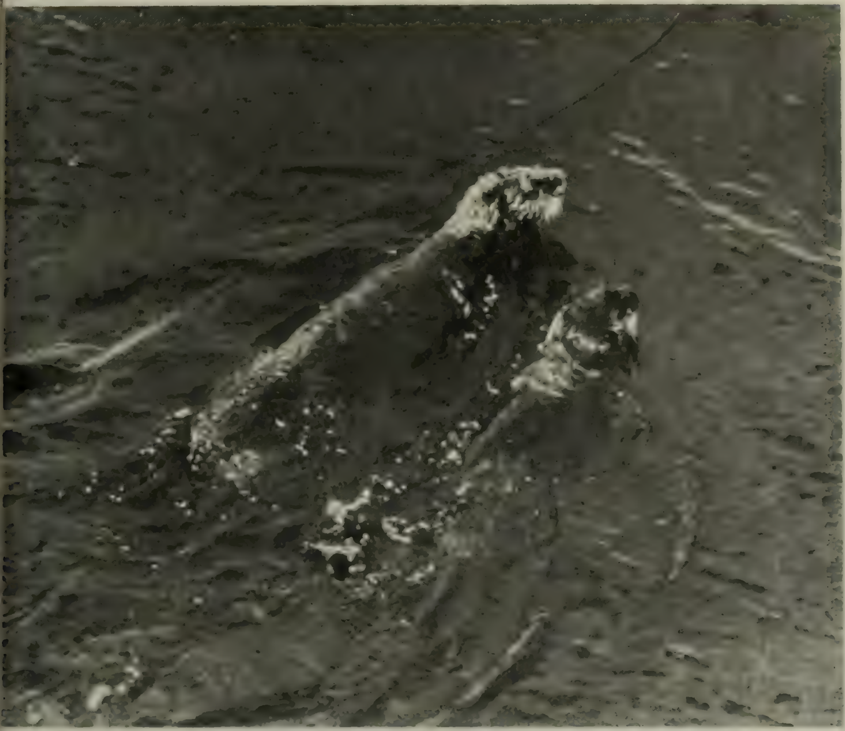


FIGURE 56.—This pup, probably about 2 months old, swims beside its mother. The mother removed the pup from her chest, placed it in the water, then swam slowly away while the pup followed. Swimming sessions, such as this, were seen often at Amchitka. They usually lasted for from 3 to 5 minutes and terminated when the mother again lifted the young one onto her chest. (KWK 1022)

SLEEP

Resting and sleeping are more frequent on the water than on and but mother otters may bring their young ashore to sleep. Newly born young often sleep while pressed against the mother's neck, under her chin. As the pup grows, it usually sleeps sprawled farther down on her chest or abdomen. When the young has reached a weight of about 10 lb. (4+ kg.), the mother holds the sleeping juvenile's head on her chest or abdomen (fig. 7) while its body floats at right angles to hers. Large juveniles sleep floating close beside and parallel to the mother. When mother and young rest on land, sleeping positions are similar (fig. 55).

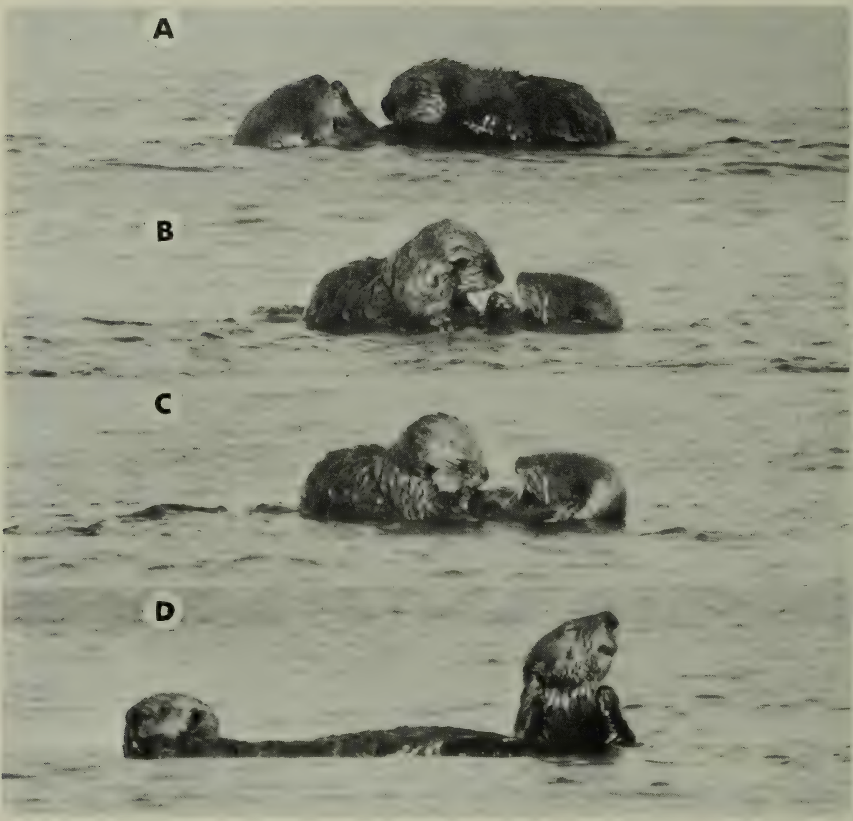


FIGURE 57.—*A*—The mother sea otter has just emerged from a feeding dive. While she eats, her pup (about 2 to 3 months old) crawls onto her belly. *B*—The pup tries to take food from the mother's paw. *C*—The mother reaches forward, placing food (a sea urchin) in the pup's mouth and paws. *D*—After finishing her food the mother rises vertically in the water while inhaling before rolling forward in another food dive. The pup continues to eat the food obtained from its mother. (KWK 65-24-13, 14, 15, and 16; 31 October 1965)

GROOMING

Shortly after birth the sea otter pup makes uncoordinated attempts to rub and groom its fur. Young animals are, however, dependent upon their mothers to keep their fur fluffy and dry. After a feeding period and before resting, the mother otter first grooms and washes her own pelage thoroughly while her pup floats nearby (figs. 41 and 43). When she has finished, she either takes her pup on her chest to preen and dry its pelage or drags it ashore. She licks the pup's fur thoroughly, then fluffs it and rubs it ry with her forepaws. When the pup defecates, the mother cleans by licking the fur in the anal region—often while doing this ne holds the pup's hind flippers above her head with her fore-aws. Mothers may continue to groom the fur of large juveniles some degree even after these animals are capable of caring r their own pelage (fig. 52).

LAY

Large pups frequently play. If two mothers with large young e feeding in the same area, the two pups may wrestle and chase ch other. Frequently the mothers disapprove of such play as ne or the other will break up the playing pair, take her young ne onto her chest, and swim to another feeding area.

During a feeding period the mother sea otter satisfies her pup's od needs before she satisfies her own. While the mother continues dive and eat, her pup explores the vicinity. If the pup sees an lult sleeping in floating kelp, it approaches quietly, then rising gh in the water descends with both forepaws on the adult's est or abdomen. Adults are tolerant of such behavior and usually dulge in a period of rolling and chasing play before abandoning e activity to leave the vicinity and continue resting.

DOPTION

Juvenile otters, lost from their mothers, may join company with tolerant adult, either male or female. Such pairs may be confused r mothers with pups. Figure 90 shows an adult male and juve-le. The two had been sleeping close to each other. The young nimal was first to become alarmed by my presence. Besides re-eating behind the adult, it placed its paws on the adult's back nd sides. When the adult eventually was aroused and moved into e water, the juvenile followed him closely and remained in mpany with him as he swam to deep water.

On 16 February 1964, a newly captured adult female (which had en given a mild injection (1 cc.) of Sparine) was placed in an closure with an orphaned juvenile female several months of ge (wt. 18 lb., 8.2 kg.). Within a few minutes the juvenile ap-roached the adult and was allowed to nurse. Two hours later the lult clasped the juvenile around the neck with her forelegs when entered the enclosure and alarmed them. Similar nursing and rotective behavior was repeated but at increasingly long intervals ntil 24 February. By this time the adult pushed the juvenile away hen it attempted to nurse and when fish were given to each nimal at feeding time, robbed it of food. During rest periods, however, the two slept in close proximity and when alarmed by a human visitor or unexpected noise they clasped each other with their forelegs.

An adult female and two juveniles of about the same size were netted together on a beach at Amchitka Island on 2 April 1955. The adult showed maternal attention to one pup and tolerated the other, allowing both to nurse. The adult, however, groomed only one juvenile and my conclusion was that the other was a stray or an orphan that had joined company with the mother and pup. Additional evidence that this may have been the situation was observed on 9 April. The pup presumed to be the mother's offspring died shortly before this group of sea otters was to be liberated at the Pribilof Islands. The surviving juvenile and the adult female were liberated together. In the water, the juvenile attempted to climb onto the adult but she ignored it and swam quickly away. We then retrieved the screaming juvenile.

The above observations indicate to me that under certain conditions a tolerant adult otter might contribute to the survival of an orphaned juvenile. It appears, however, that under conditions of stress and during times of food shortage an adult might give little more than companionship toward the survival of an "adopted" juvenile.

Relation to Other Animals

Within its usual habitat, which includes the beach, offshore rocks, and water out to a depth of about 30 fathoms (60 m.), the sea otter is often near other mammals and birds. Two species, the Bald Eagle and killer whale, are discussed under "Predation."

Harbor seals and sea otters often haul out on the same rocks and rest or sleep near each other. Each species appears to ignore the other; no interspecific strife of any kind was ever seen. In general, harbor seals and sea otters appear to prefer slightly different resting places. At St. Makarius Point on Amchitka several large rocks are located a few meters offshore. Some of these were habitually used by sea otters and others by harbor seals. If a sea otter found a harbor seal on a favorite resting spot, it selected another place. On several occasions a harbor seal was seen to cause a sea otter to move. When the moving seal jostled the sea otter in attempting to pass, the otter got up and moved.

Interspecific competition for food is probably negligible. The harbor seals at Amchitka feed primarily on octopus and Atka mackerel (Kenyon, 1965a). Both of these species may be taken y sea otters but our fishing operations indicated that fish popuations at Amchitka are large. Also, sea otters tend to feed on edentary fish that were not found in seal stomachs.

Steller sea lions seldom chose places that were favored by sea tters for resting on land. When sea lions passed near sea otters hat were diving for food, the otters usually raised themselves igh in the water to stare at the sea lions. Otherwise the two pecies ignored each other.

Parasitic worms *(Terranova decipiens,* for example) which comnonly infest the harbor seal and sea lion, enter the encysted stage n fishes. Sea otters that eat fish also become infested. *Halarachne niroungae,* a nasal mite commonly found in harbor seals, were arely found in wild sea otters. These may have been picked up by he sea otters at a location commonly used by the two species. n the wild these pinniped parasites seemed not to seriously affect ea otters.

Glaucous-winged Gulls frequently obtained scraps from otters vhile they fed on fish. I did not see gulls attempt to take fish way from a feeding otter but they swam close to feeding otters r hovered above them ready to take scraps (fig. 58). When we vere searching for sea otters during census studies, we found hat gulls were a useful indicator of the location of feeding otters. group of gulls sitting together on the water usually marked he location where an otter would emerge from a food-gathering live.

Unlike many other mammals, sea otters at Amchitka did not ppear to recognize the calls of birds as possible indicators of pproaching danger. On a number of occasions, Black Oysteratchers *(Haematopus bachmani)* and Emperor Geese *(Philacte anagica)* were alarmed by our approach when we were stalking ea otters that were hauled out on the beach. Although the calling irds sometimes flew directly over the otters, they appeared to ay little or no attention to them.

Rats *(Rattus norvegicus)* introduced to Amchitka during World Var II often entered the sea otter enclosure to search for food craps. On one occasion a rat approached a sea otter that was rooming its fur while resting on its back beside the pool. After niffing at the sea otter's side, the rat suddenly jumped onto the tter's chest. Quickly the otter struck the rat with its forepaw, nocking it a distance of nearly a meter.

In general, it did not appear that the sea otter was in serious ompetition with other mammal and bird species within its environ-

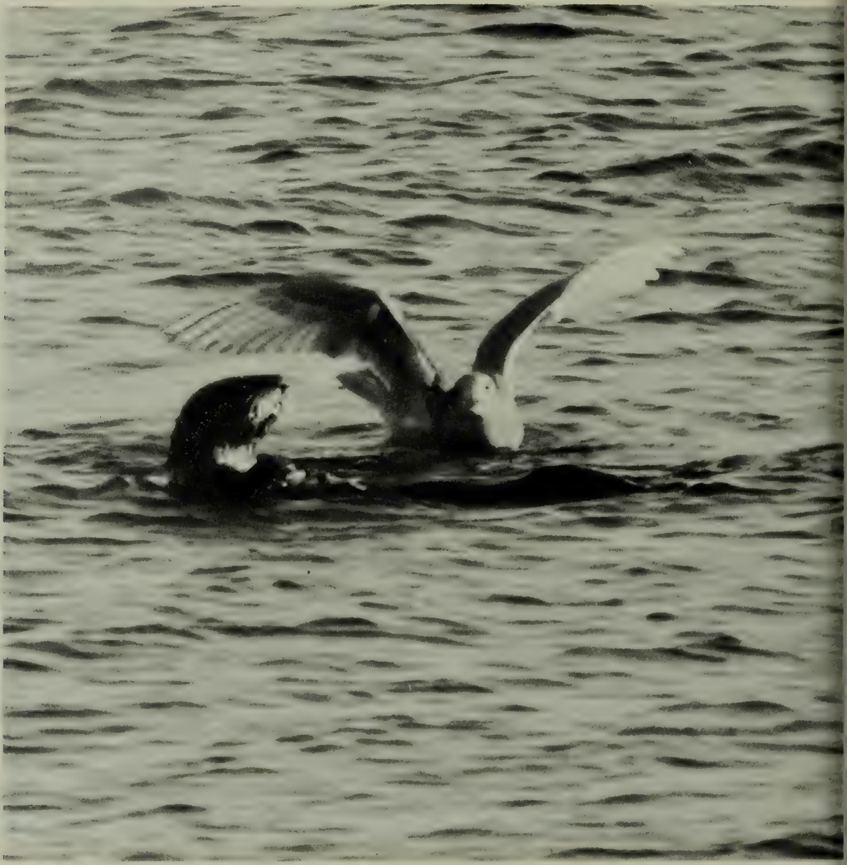


FIGURE 58.—An immature Glaucous-winged Gull waits expectantly for fish scraps discarded by a feeding sea otter. Groups of two or three gulls sitting together on the surface in the Aleutian area usually indicated the location of a sea otter feeding on fish. While the otter was beneath the surface the gulls waited near the location where they expected it would emerge from a food-gathering dive. (KWK 57–31–2)

ment at Amchitka or that any interspecific strife existed. Perhaps in periods of food scarcity, survival of gulls is enhanced through their utilization of the otters' discarded food scraps.

FOOD AND FEEDING BEHAVIOR

In this section, methods of food gathering and consumption, the kinds and quantities of foods eaten, and the food requirements of sea otters in the wild and in captivity will be discussed. This information was gathered by means of field observation, quantitative and qualitative studies of stomachs and feces, and data gathered from otters held on Amchitka Island, the Woodland Park Zoo, Seattle, and the Tacoma Aquarium.

The amount of food required by the sea otter is greater than that of most animals of comparable size. The sea otter stores body fat but it does not accumulate fat in quantities comparable to the blubber stored by most marine mammals. Because it lacks an insulating blubber layer, the sea otter is dependent for warmth in its chilly habitat upon its fur and upon the rapid metabolic use of energy from food. Passage of food through the gastrointestinal tract is rapid. Food marked with red dye passed through an otter in about 3 hours (Dr. James A. Mattison, personal communication).

Periods of fasting which are characteristic of other marine mammals, such as certain cetaceans and pinnipeds, would prove fatal to the sea otter. Its vitality is maintained by a relatively high and constant consumption of food.

Studies comparable to ours in Alaska were conducted in the Kuril Islands by Soviet biologists Nikolaev and Skalkin (1963) and Nikolaev (1965b).

Feeding location

Sea otters habitually gather their food from the bottom or near it in salt water ranging in depth from a few feet, in the intertidal or littoral zone, to about 20 fathoms (40 m.). This is the greatest depth from which we took an otter having food in its stomach. The majority of otters feed within about one-half mile of shore. In certain areas, particularly off the north shore of Unimak Island in the Bering Sea, where shallow water extends far from shore, they commonly range 3 to 10 miles offshore and one was seen in this area about 17 miles from shore in water about 30 fathoms (56 m.) deep (see table 10).

That certain individual animals would learn to feed on pelagic forms and thus divorce themselves from the necessity of remaining in relatively shallow water is improbable. Observations indicate that the sea otter subsists only on benthic organisms. Wide, deep passes between islands, which prevent bottom feeding, appear to act as a barrier to the spread of sea otter populations. (See Distribution and Numbers.)

Food Gathering

Many observations indicate that the sea otter uses its forepaws primarily to gather food and that the tactile sense is important in locating food organisms. A captive female with good eyesight was offered food in a bucket about half full of turbid water. In one instance the bucket contained about 200 small crabs *(Pachygrapsus)*, 4 blue mussels *(Mytilus edulis)*, and a number of pebbles of various sizes. The otter had eaten both organisms before but showed a preference for mussels. When the bucket was presented to her, she immediately reached to the bottom with both forepaws, her chin on the edge of the bucket, and within a few seconds retrieved the four mussels. She made no attempt to place her head in the bucket or to look into it. Thus, she demonstrated a high reliance on her tactile sense in selecting the mussels from among pebbles and crabs.

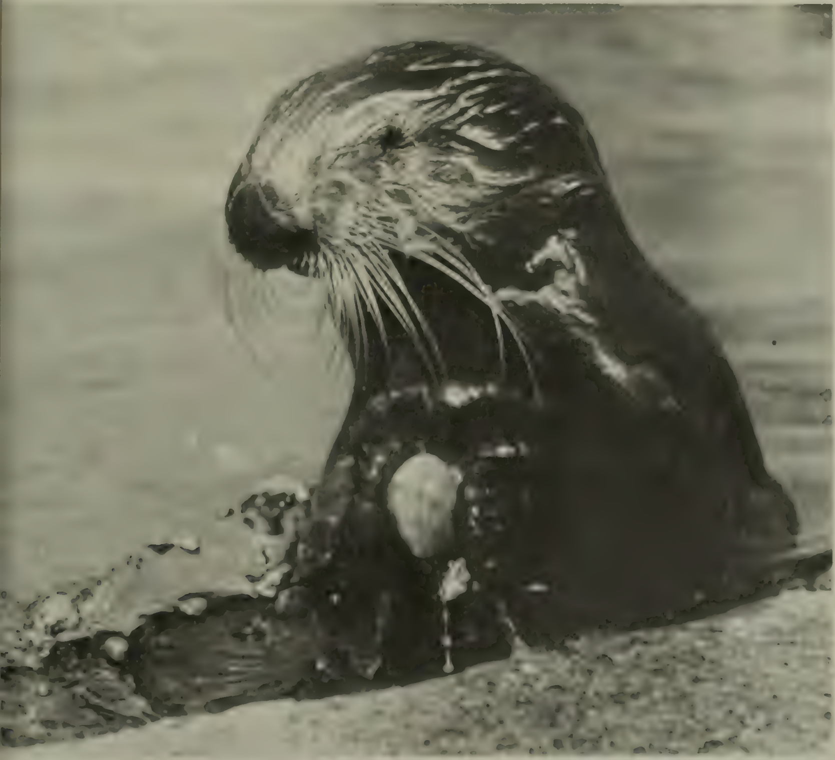
Numerous observations of Susie, during the 6 years that she lived at the Woodland Park Zoo, indicated that she relied heavily on her tactile sense while retrieving food placed in her pool. She was blind in her right eye when captured and blind in both eyes for over a year before death. During this period of total blindness she continued to find food and to select the most desired kinds, using her paws to select it. I have observed several healthy wild otters that were blind in one eye but have seen only one that was apparently blind in both eyes. This animal was emaciated and near death. Existence without sight among breakers in the harsh coastal environment would probably be impossible even if food could be found.

Wild otters normally terminate feeding activities before dark and do not begin morning feeding until after sunrise. Mothers which must provide for their young, however, may continue diving for food after dark. I watched a mother diving one evening until darkness prevented further observations. During the period shortly before visibility was lost, the otter continued to bring food items (mostly sea urchins) to the surface in the usual quantities.

thus inferred that she relied primarily on her tactile ability to ıd food.

Sight under water, however, is apparently sometimes used in cating food. Captive otters on Amchitka often searched the ɔttom of their pool by swimming on the surface, head submerged. ood items on the bottom were quickly located visually in this anner and retrieved.

The vibrissae may also aid in the search for food. Captive otters, ıving an abundance of easily located food, abrade the vibrissae a minor degree; they may reach a length of 10 to 12 cm. (fig. 59). he vibrissae of wild otters may be worn off short, to a length of ɔout 1.5 to 2.5 cm. Presumably the abrasion occurs during the arch for food among rocks.



IGURE 59.—A captive otter pounds a clam (*Protothaca*) on the cement edge of her pool. This otter came from Amchitka where breaking shells of food organisms by pounding was not observed. The whiskers of captive otters grow long, as illustrated here. In the wild the whiskers are usually abraded and short. Presumably wear occurs during the search for food among rocks. (KWK 57–24–16)

It would appear that under usual circumstances the sea otter does not use its teeth under water. On many occasions I have seen sea otters come to the surface clasping living fish to their chests with their forepaws. After surfacing, each otter grasped the fish's head in its jaws and killed it, suggesting that the teeth are not used to kill fish beneath the surface.

That otters may use their teeth beneath the surface when necessary to obtain food was demonstrated at Amchitka. In Constantine Harbor the otters apparently learned that our net floats marked an abundant supply of fish. We often saw an otter on the surface, eating, near the floats. When we pulled the nets, we found fish that the animals were unable to remove but which they had partly eaten underwater. Usually about half the fish was left, but occasionally only the head and pectoral girdle remained. The fish were not bitten off cleanly; they were chewed, leaving strips of skin and tooth-marked shredded flesh attached to the entangled portion. The frequency with which we saw otters eating fish on the surface near the nets indicated that they were able to remove a considerable number. Rarely did otters become entangled in the nets and drown.

The stomach of one adult male contained a number of large clam siphons. The siphons, with adhering fragments of mantle and muscle tissue, appeared to have been ripped from the clams by the otter's paws or teeth. Visceral material from these clams was lacking in the stomach. Presumably the siphons protruded from the sea's floor and the remainder of the clam was not dug out.

Fisher (1939) postulated that the sea otter used either a rock or its canine teeth to remove abalones from the bottom. Cox (1962) presents convincing evidence that the sea otter uses a rock to break the abalone shell; that the otter then removes the viscera and, after the abalone dies and releases its hold on the rock bottom, brings it to the surface where it eats the muscle from the remainder of the shell. The behavior of a captive otter, which persistently pounded a rock against an underwater drain cover until it was able to damage the fastening and remove it (Kenyon, 1959), lends strong support to the use of a rock rather than the teeth in obtaining abalones. The canine teeth are probably not of sufficient strength to remove any but small abalones from the bottom.

A unique habit related to feeding in the sea otter, that of pounding hard-shelled mollusks against a stone or other mollusk held on the chest, has been given much attention, most recently by Hall and Schaller (1964). Although this habit is frequently observed in California sea otters, it is rarely observed in the parts of Alaska where I have watched sea otters feeding or in Soviet waters (Barabash-Nikiforov, 1947). At Amchitka, I have twice observed subadult otters pounding a chunk of coralline algae held between the forepaws against another resting on the chest. This behavior appeared, however, to be play as the animals did not attempt to find food in the algae after breaking it but discarded the material after a few minutes of intermittent pounding.

That Alaska sea otters are capable of using the pounding technique was demonstrated by a captive taken at Amchitka Island. Soon after Susie had become accustomed to captive conditions at Seattle, several small stones and whole butter clams *(Saxidomus)* were placed in her pool. Although she used a stone as an anvil on which to break the clams, she used it in other ways too. The stone was also held in the paws and used as a hammer. Also, if a large number of clams were given to her she often neglected to obtain the stone but pounded the clams against each other (fig. 60). Clams, sea urchins, fish, and rocks were pounded against the cement-constructed side of the pool (fig. 59).

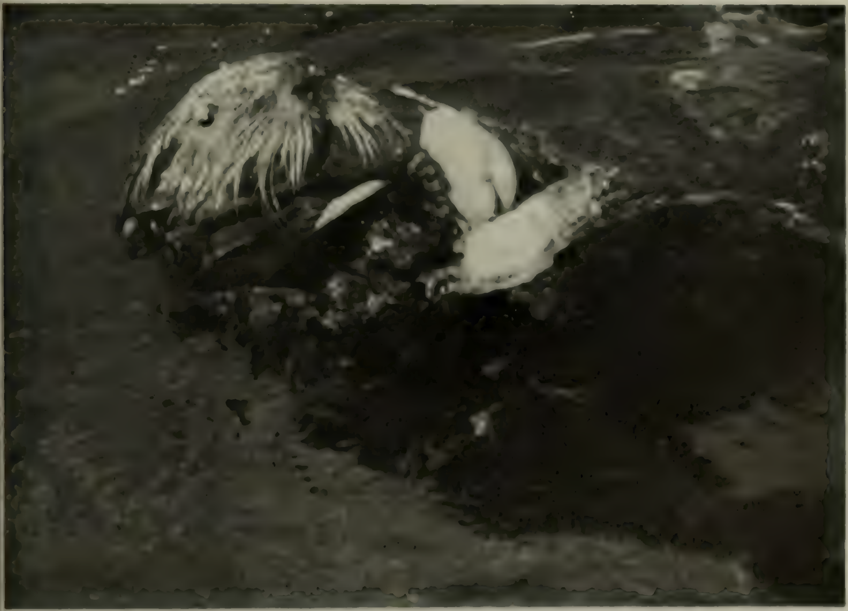


FIGURE 60.—Clams (*Saxidomus*) were broken open by pounding one against another held on the chest. If a rock was handy, this captive otter pounded clams against it. Clam meats are scooped from the shell with the tongue and lower incisors. (KWK 57-22-32)

What Food is Eaten

The food of the sea otter consists predominantly of benthic invertebrates and fish. At Amchitka Island fish predominate (50 percent by volume), mollusks are second in importance, and echinoderms (mostly sea urchins) third (table 11). In other areas, mollusks and echinoderms are found to predominate.

That the feeding habits of the sea otter vary in different areas, in accordance with the abundance of food organisms, is indicated by the statements of Snow (1910), who claimed to have examined hundreds of stomachs. He stated that he did not find clams among the food species eaten by the sea otter and that—

> I have never noticed any traces of the shells of clams, or limpets, or mussels in the stomachs I have examined, but found as a rule, the remains of crabs, sea urchins, sea-squirts, and what looked like fish spawn.

He also said that he very seldom found any remains of "ordinary fish, the bones of which would immediately prove its presence." He adds that the sea otter "finds no difficulty in chewing up good-sized crabs, which judging from the contents of the many stomachs I have opened and examined, appear to be its chief food." Mr. H. P. Hansen, a king crab *(Paralithodes platypus)* fisherman told me (1964) that in the Andreanof Islands he "often sees sea otters eating king crabs, sometimes quite large ones."

Although a large variety of organisms is eaten, individual otters appear to have certain food preferences. "Individual sea otters often prefer a certain food in the assortment of food characteristic to them" (Barabash-Nikiforov, 1947). Some adult males at Amchitka subsist primarily on fish and rarely eat sea urchins. In general, at Amchitka it appears that the otters fall into two groups—those eating mostly fish and those eating mostly invertebrates. The fish eaters, as would be expected, show a higher degree of infestation with certain parasites (principally *T. decipiens)*

TABLE 11.—*Volume and classification of food found in 309 sea otter stomachs from Amchitka Island, Alaska*

[Only stomachs containing food are considered. The samples include 107 stomachs collected in January and February 1962, 20 stomachs collected in October 1962, and 182 stomachs collected in March and April 1963]

Food item	Total volume (milliliters)	Percent of total volume
Annelid worms	929	1
Crabs, shrimp, etc.	467	<1
Mollusks	34,895	37
Echinoderms (mostly sea urchins)	10,020	11
Tunicates	363	<1
Vertebrates (fish)	46,518	50

than those subsisting primarily on invertebrates. Also, the bones of "fish-eaters" are white but the bones of those otters utilizing invertebrates—including many sea urchins—are stained purple by the biochrome polyhydroxynaphthoquinone (Scott, *in* Fox, 1953, footnote p. 195).

Much indigestible material is swallowed incidentally in the consumption of nourishing food. Part of the test of almost every sea urchin eaten is crushed by the postcanines and swallowed. Many stomachs contain scraps of red and brown algae. Seaweeds, as Barabash-Nikiforov (1947) and Fisher (1939) indicate, cannot be considered an otter food. This material appears in the feces unaltered in appearance, except for the wear and abrasion encountered during passage. I have often seen such scraps of kelp eaten when entangled among the spines of sea urchins. Its occurrence in stomachs is accidental.

Small pebbles, gravel, and bits of hard clay occurred in 14 percent of 475 stomachs from Amchitka. One stomach contained 325 small stones. Stones are also commonly found in the stomach of fur seals and sea lions (*Eumetopias* and *Zalophus)* and no sure explanation of their presence is known. Although the "gastroliths" of pinnipeds are usually waterworn or smooth, the stones we found in sea otter stomachs often looked as if they had been freshly broken apart; they were seldom waterworn or smooth. No reason for the swallowing of this indigestible material is known.

After food has been selected from the substrate, it is stored for transportation to the surface in folds of loose skin (fig. 11) which extend from the axilla across the chest (see Kirkpatrick et al., 1955; Barabash-Nikiforov, 1947). If only enough food is gathered to fill the pouch on one side, it is stored under the left foreleg and paw. If a large quantity is gathered, it may be stored and carried in the chest pouches under both forelegs.

When an otter captures a large octopus or fish and satisfies its appetite before it consumes the entire organism, it often sleeps on the water's surface with the remains of such an uneaten meal clasped to its chest. After sleeping for awhile, the otter awakens and continues to eat. Uneaten food, however, is not retained for an extended period. After the animal has nibbled its food intermittently for perhaps 2 hours, and then begins to groom, the food is forgotten and allowed to sink. Captives retrieve discarded food and again eat after grooming and resting.

On occasions when we have pursued otters with an outboard motor-powered dory we have interrupted their feeding. When this occurs, the otters do not relinquish food remaining in the chest pouches. In one instance we interrupted a feeding adult male and pursued him for nearly 2 hours. He invariably evaded us by surfacing at unpredicted places. We finally abandoned as futile our effort to capture him and he immediately continued to eat the sea urchins he had carried under his left foreleg during the entire chase.

When captive otters are given food on land, the items are transferred to the chest pouch under the left foreleg with the assistance of the right paw. The otter then walks on three legs to return to the water with the food. If the quantity of food exceeds the capacity of the pouch under the foreleg, additional food may be grasped and carried in the jaws.

A captive, resting on her side near her pool, was able to place 18 clams *(Protothaca)*, ranging from about 3 to 4 cm. in greatest diameter, under her left foreleg. When a 19th was added, most of the others fell out. Eight clams were easily carried under the left foreleg while the otter walked on three legs about 3 m. to the pool.

Where Food is Eaten

Sea otters normally bring food items to the surface and, using their forepaws, pass the food to the mouth and eat while floating on their backs. Hooper (1897) probably misinterpreted a statement by Steller (1751) when he stated that "the otter haul out upon the land to feed on the sea urchins and the other shellfish exposed at low water." Wild sea otters do not carry food from the water to exposed rocks or beaches and normally do not emerge from the water to obtain food. I know of no record of a wild otter voluntarily consuming food on land.

A wild otter that habitually frequented the inshore water near our fish-cleaning platform quickly learned to take fish scraps from our hands. After several weeks he often left the water to beg for food while following us about. Even though he accepted pieces of fish as far as 25 m. from the water (fig. 61), he always carried the food back to the water before eating it.

Captive otters, if they are denied access to water, will eat while lying on a dry surface, but usually reluctantly. Captives having free access to water and dry areas, voluntarily leave the water to obtain food when they are hungry (fig. 62) but return to the water to eat it.

Periodically (usually at intervals of 20 to 30 seconds) while consuming food at the surface, the sea otter stops eating and rolls

GURE 61.—A wild sea otter accepts a fish head from Innokenty Golodoff. This otter frequented the area where we discarded fish scraps. He soon became tame and emerged from the water to follow us as far as 25 meters from the water to beg for food. He never consumed food on shore but carried it in his mouth or under the left foreleg to the water where he ate while floating on his back. (KWK 57–34–31)

er (fig. 63). This action washes food scraps from the chest here they were either purposely discarded or accidentally opped.

Stomach Analyses

The best information available on food habits of the sea otter as derived from the examination of 475 stomachs from otters ost of which were shot at Amchitka Island (table 12). Previously ilke (1957) studied stomachs from five otters taken there. Also, e examined a number of stomachs of otters found dead or dying beaches.

Stomachs were removed from sea otters as soon as practicable, ually within 2 to 3 hours after death. They were then injected ith a 10 percent formalin solution and immersed in a large coniner of formalin solution, where they soaked for several days.

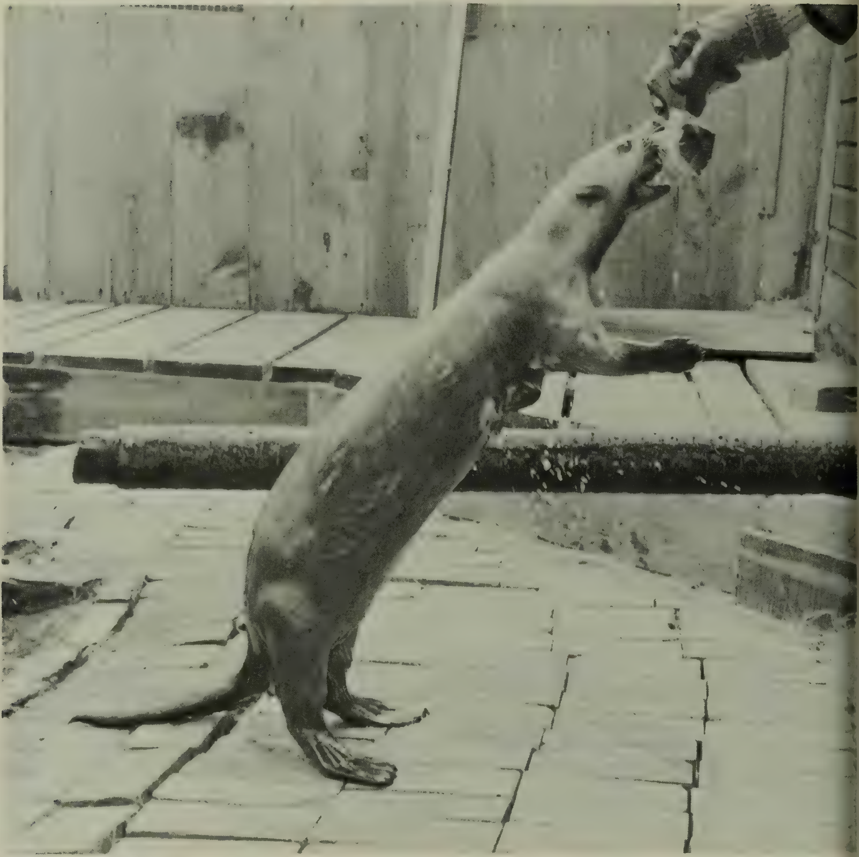


FIGURE 62.—A captive adult female sea otter clasps one piece of fish to her chest under her left foreleg while she reaches with her teeth to grasp another. After receiving all the food she could carry under the foreleg and in her teeth, she returned, walking on three legs, to the water before she consumed her food. The long outer or fifth digit of the hind foot is illustrated. (KWK 59–13–10)

TABLE 12.—*Sea otter stomachs examined*

[This listing includes animals presumed to be healthy. Most of them were shot. Animals found dead and dying on beaches are excluded]

Date	Location	Stomachs empty		Stomachs with food		Total examined
		Number	Percent	Number	Percent	
6–10 June 1960	Shumagin Islands	4	67	2	33	6
8–10 July 1960	Bering Sea [1]	2	50	2	50	4
22 Jan.–9 March 1962	Amchitka Island	32	23	107	77	139
26–29 Oct. 1962	do	4	17	20	83	24
14 March–2 April 1963	do	119	39	183	61	302
Total		161	34	314	66	475

[1] Otters were taken at sea off the north coast of Unimak Island.

GURE 63.—At frequent intervals, while floating on the surface and consuming food, the sea otter stops eating and rolls about its longitudinal axis through 360°. This action washes food slime and scraps from the chest. It is an important behavioral characteristic that helps to keep the fur clean and waterproof. Food slime destroyed the water-resistant and insulating qualities of the fur of captive otters that were not given access to water. In nature, sea otters eat only in the water—never on shore. (KWK 1021)

fter removal from the pickling bath, they were packed in wide-
outhed, 5-gallon cans and shipped to the Seattle laboratory.
fter removal from the stomach, the weight and volume of the
ntents were measured, the food species were identified, the
rcentage composition of each species was evaluated, and all
rtinent data for each specimen was entered on a 3-by-5 card.
collection of identified invertebrates and fish, accumulated at
e Seattle laboratory for the study of marine mammal food
bits, aided identification of food species. Food organisms that
uld not be identified locally were sent to specialists who examined
em and made identifications whenever this was possible.

If a feeding otter swallows the test, shell, or bony parts of a
od organism, the identification of food species may not prove
fficult. Such hard parts are usually not crushed sufficiently to
literate all diagnostic characteristics. Often, however, the feed-
g otter discards most or all of the hard parts, making identi-

fication of food species difficult or impossible. As the stomachs were examined, a collection of unknowns was accumulated. Food organisms found in various stages of mutilation in different stomachs eventually furnished material that made possible the recognition of small fragments or badly mutilated food in other stomachs. The food species found in sea otter stomachs taken at Amchitka are shown in table 13 and a general account of these organisms and the sea otter's habits relating to their consumption follows.

Annelid worms were usually torn into pieces several centimeters long and the pieces swallowed with minor damage from mastication. Considerable slimy mucus accompanied annelid remains.

Crabs were torn to pieces and usually the carapace was not among the stomach contents. The larger legs and chelipeds were usually thoroughly crushed.

Among the mollusks that were found, various techniques of ingestion were indicated. Small chitons were slightly crushed and often swallowed nearly intact. Large ones *(Cryptochiton stelleri)* were thoroughly crushed and torn, reducing them to small pieces. The flesh of limpets was scooped from the shell and swallowed nearly intact and the shell discarded. Rarely was a fragment of limpet shell swallowed.

TABLE 13.—*Frequency of occurrence of food species in 309 sea otter stomachs from Amchitka Island, Alaska*

	Number of stomachs having item—				
Food organism	Of 107 stomachs February–April 1962	Of 20 stomachs October 1962	Of 182 stomachs March–April 1963	Total	Percent
Annelida			5	5	
Ribbon worm *Emplectonema* sp.	1	—	—	1	
Sand worm *Nereis* sp.	2	—	—	2	
Lug worm *Arenicola* sp.	5	—	—	5	
Total	8	—	5	13	2
Arthropoda:					
Crustacea:					
Olive green isopod *Idothea (Pentidotea)*	6	—	3	9	
Amphipods (probably incidental)	5	—	6	11	
Shrimp *Sclerocrangon boreas*	1	—	—	1	
Hermit crab *Pagurus* sp.	3	3	9	15	
Crab:					
Cancer sp.	1	5	—	6	
Telmessus cheiragonus	1	1	—	2	
Paralithodes? (larval)	2	—	—	2	
Placetron wosnessenski	5	—	1	6	
Hapalogaster sp.	—	—	5	5	
Unidentified	—	—	4	4	
Shrimp unidentified	—	—	1	1	
Total	24	9	29	62	7

ABLE 13.—Frequency of occurrence of food species in 309 sea otter stomachs from Amchitka Island, Alaska—Continued

	Number of stomachs having item—				
Food organism	Of 107 stomachs February–April 1962	Of 20 stomachs October 1962	Of 182 stomachs March–April 1963	Total	Percent
llusca:					
Amphineura:					
Lined chiton *Tonicella* cf. *T. marmorea*	1	—	—	1	
Mossy chiton *Mopalia* sp.	1	—	—	1	
Giant chiton *Cryptochiton stelleri*	4	5	8	17	
Chiton unidentified	—	—	2	2	
Gastropoda:					
Limpet *Acmaea* sp.	5	5	10	20	
Snail:					
Thais sp.	1	—	4	5	
Natica clausa	1	—	—	1	
Buccinum sp.	10	—	7	17	
Argobuccinum oregonensis	6	—	8	14	
Gastropod unidentified	—	—	3	3	
Pelecypoda:					
Cockle *Clinocardium ciliatum*	2	—	1	3	
Clam:					
Liocyma viridis	1	—	—	1	
Serripes	1	—	—	1	
Macona sp.	—	—	3	3	
Unidentified	—	—	2	2	
Mussel:					
Musculus vernicosa	10	12	24	46	
Volsella volsella	22	6	21	49	
Pearly monia *Pododesmus macroschisma*	28	2	20	50	
Cephalopoda: *Octopus* sp.	12	4	14	30	
Mollusk unidentified	—	—	3	3	
Total	105	34	130	269	31
hinodermata:					
Asteroidea:					
Blood star *Henricia* sp.	15	2	11	28	
Six-rayed star *Leptasterias* sp.	29	—	28	57	
Starfish *Ceramaster* sp.	6	—	6	12	
Brittle star Ophiuroidea	1	—	13	14	
Echinoidea: Green sea urchin *Strongylocentrotus drobachiensis*	71	17	92	180	
Holothuroidea: Sea cucumber *Cucumaria* sp.	17	4	5	26	
Total	139	23	155	317	37
rdata:					
Tunicata: Tunicate (2 species)	4	1	6	11	1
rtebrata:					
Osteichthyes:					
Sablefish *Anoplopoma fimbria*	1	—	—	1	
Rock greenling *Hexagrammos superciliosus*	5	1	9	15	
Atka mackerel *Pleurogrammus monopterygius*	4	2	3	9	
Red Irish lord *Hemilepidotus hemilepidotus*	18	4	14	36	
Globefish *Cyclopterichthys glaber*	22	—	87	109	
Cottidae unidentified	1	—	—	1	
Fish and fish eggs unidentified	5	—	—	5	
Total	56	7	113	176	22
Grand total				848	100

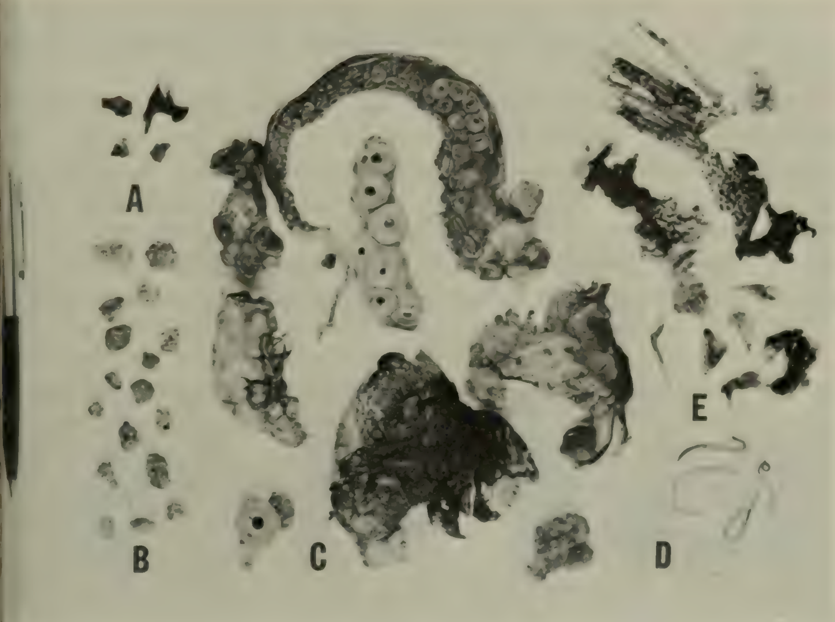
Snails were recognizable in stomachs because the tough muscular foot was usually little affected by chewing and often the chitinous operculum remained intact and attached to the foot. The shells of small snails *(Buccinum* sp.) were often swallowed but those of large ones *(Argobuccinum oregonensis)*, except the operculum, were not.

Clam shells, except those from small individuals, were seldom present in the stomach. One stomach contained about 2 liters of clam meats, the foot and viscera of many almost intact, but not one scrap of shell. The shell of thin-shelled clams *(Serripes groenlandicus)* were fragmented and swallowed in considerable quantity.

The small mussel *Musculus vernicosa*, which was consumed in large numbers, was usually swallowed whole. Individual mussels may appear in the feces with the valves still intact. Many fragmented shells of larger mussels, such as *Volsella volsella*, sometimes appeared in feces. Often, however, stomachs having a number of mussels contained little or no shell. The viscera were recognizable by their orange color and attached byssus.

The pearly monia *(Pododesmus macroschisma)* appeared in 5(stomachs, often in considerable quantity but only a few tiny fragments of shell were found. Observations of feeding otters revealed that, after slightly loosening the valves with one canine tooth, the two valves were twisted horizontally past each other between the paws so that the viscera could be quickly scooped with the lower incisors and tongue from the half shell to which it adhered. Seldom are the shells broken during this procedure Since few hard parts of this species are ingested, it is not revealed as an important food species in fecal examinations.

Octopuses are eaten with particular enthusiasm by captive otter and wild otters also appear to relish them. Because of its siz (commonly 2 to 4 lb.), the octopus constitutes an excellent foo source at Amchitka. Apparently otters are not disturbed by th writhing tentacles of this mollusk. Pieces of arms are bitten of and eaten when one moves within range of the paws and mouth Other tentacles wrap themselves about the otter's head, legs, an body while the otter continues to tear off and swallow chunks o flesh (fig. 64). Occasionally a sucker attaches itself to the otter' palate but it is quickly torn loose by the extended claws of th forepaws. A large octopus may furnish sufficient food for mor than one feeding period. The chitinous beak of the octopus ma or may not be swallowed. Even if it is, fecal examinations do nc reveal the importance of this food species.



IGURE 64.—Food taken from a sea otter stomach: *A*—fragment of octopus jaws; *B*—small pebbles; *C*—octopus tentacles and mantle; *D*—ascarid worms (probably *Terranova decipiens*); *E*—fins, skin, and opercular spines of the red Irish lord (*Hemilepidotus hemilepidotus*). The sea otter's teeth are not adapted to cutting; the tough octopus flesh is swallowed in chunks that show little effect of chewing. (The pencil is 12 cm. long.) (KWK 1013)

A captive otter was fed 5 lb. (2.3 kg.) of squid *(Loligo)* daily. efore beginning to eat each squid he removed the pen by grasping s tip between his incisors and drawing it from the mantle. He en discarded it over his left shoulder by turning his head quickly the side.

Starfish of several species are of minor value as a sea otter food. lthough a number of stomachs (111) contained starfish remains, e volume was small. I have seldom observed a feeding otter that e an entire starfish. The otter usually tears off and eats one or vo arms of a starfish, then loses interest and discards the re- ainder.

Fecal and stomach examinations indicate that the green sea chin *(Strongylocentrotus drobachiensis)* is frequently eaten and is food has been considered the most important, if not essential, em in the diet of the sea otter. With captive sea otters, Shidvskaya (1947) stated that "Longer interruptions than 5 days in feeding sea urchins should not occur." Evidence that this assumption is not always true is presented under "Relative Values of Sea Otter Foods."

The method of ingesting green sea urchins varies according to the size of the sea urchin and also somewhat according to the habits of individual otters. Stomach examinations and observations of feeding otters indicate that some animals habitually ingest more of the test than others. Small urchins are crushed by the molars and usually at least part of the test is swallowed (fig. 65). Large urchins may first be bitten with the postcanines on one side,

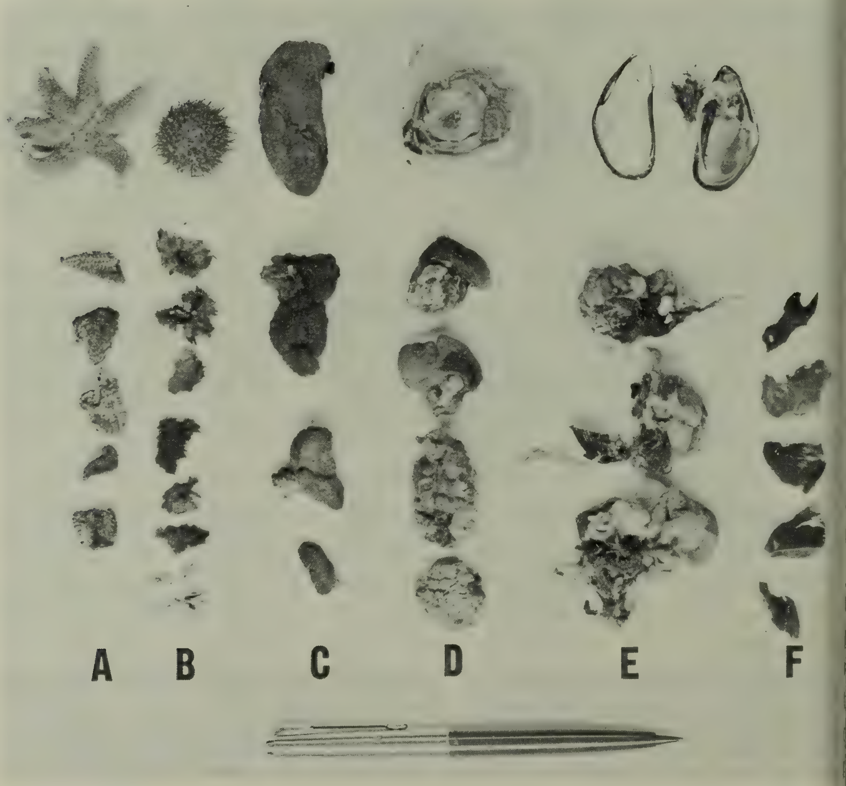


FIGURE 65.—Intact sea otter food organisms are shown at the top of column *A* to *E*, and partially digested fragments of the same species remove from stomachs are shown below. *A*—six-rayed star (*Leptasterias* sp.); *B*—green sea urchin (*Strongylocentrotus drobachiensis*); *C*—sea cucumbe (*Cucumaria* sp.); *D*—pearly monia (*Pododesmus macroschisma*); *E*—mussel (*Mytilus edulis*); *F*—fragments of marine algae. Algae, which i voided undigested in the feces, is not a food species but is eaten accidentally (KWK 1011)

fracturing the test. Then, with the aid of paws and teeth, the otter is able to open the test and with the lower incisors and tongue to scoop out the exposed viscera and gonads (Hildebrand, 1954). Large urchins may also be opened primarily with the paws. The top of the urchin is cradled against the palm of one paw while the digits and palm of the other exert pressure on the test surrounding the urchin's oral opening, crushing it inward. The urchin may be rotated to facilitate application of pressure. When the test is sufficiently weakened the teeth are used to remove the broken test so that the contents may be scooped out. The empty test may be tossed aside with the paws or dropped on the chest or belly while another item is eaten.

Sea cucumbers appear to be of minor importance in the diet of the sea otter, they appeared in only 26 stomachs. They are tough and showed relatively little multilation from chewing (fig. 65). We did not give them to captive otters but Shidlovskaya (1947) says that they were eaten reluctantly by her captives.

Tunicates, having a tough leathery covering, do not appear to be an important food. A few individuals were in 11 stomachs.

Fish, particularly the globefish *(Cyclopterichthys glaber)*, contributed the greatest food volume (50 percent of all food volumes combined) among stomachs taken at Amchitka. It is evident that this food source, along with mollusks, is of major importance.

The identification of fish species eaten is sometimes difficult because sea otters often discard diagnostic bony plates from the heads of fish. Also, the bones that are swallowed may be severely crushed during mastication. The variety of fish eaten is not large and a series of specimens was accumulated during stomach examinations that enabled us to identify most fish remains.

The fish taken are usually bottom-inhabiting forms and are somewhat sedentary or sluggish. The red Irish lord (fig. 64) and globefish, both sluggish species, occurred in 75 percent of the stomachs containing fish. Information obtained from hundreds of trammel net hauls at Amchitka, as well as data from the stomachs of harbor seals taken there, indicate, however, that the rock greenling and Atka mackerel may be more abundant than the red Irish lord or globefish. However, they are more active than these two species and possibly for this reason are less frequently captured by the otters.

The sea otter does not appear to be well adapted to the capture or consumption of fish. The dentition is very unlike that of seals and porpoises. All marine mammals that eat fish, except the sea otter, capture them with their teeth and swallow them without mastication (seals and sea lions may, however, tear chunks from a fish that is too large to swallow intact). The sea otter apparently captures fish with its paws and all fish flesh found in stomachs had been torn into chunks that were crushed before swallowing. No fish were swallowed whole.

Thus, the sea otters' manner of capturing and eating fish is unique among marine mammals. After the fish was brought to the surface and killed by a crushing bite at or near its head, it was held in the paws and chunks were torn from it, masticated to a moderate degree and swallowed. Some chunks of fish found in stomachs measured about 3 x 4 x 5 cm. Eating usually began at the fish's tail and often all or most of the head (particularly of the cottids) and viscera were discarded. Strong adult males clasped the fish body firmly with the forepaws and extended claws, then, starting at the anterior end ripped the skin with the canines and incisors from first one side, then the other. The flesh and bones were then rapidly eaten like a candy bar. Globefish, being scaleless and having soft bones, were consumed almost in their entirety.

In the Shumagin Islands four adult male and one adult female sea otters were taken on 6 and 7 June 1960 at Simeonof Island and one female on 11 June at Little Koniuji Island. Four stomachs were empty. The stomach contents of two males are shown in table 14.

Of interest is the fact that among the contents of the two stomachs which had a combined volume of 3.48 liters (3.7 qt.), mostly clam meats, there were no scraps of clam shell. For this reason, the species eaten could not be positively identified. Dr. G. D. Hanna did, however, tentatively identify the large siphons as belonging to the Washington clam *(Schizothaerus nuttallii)*. Perhaps this large clam was not removed from the sand bottom or the shell could not be broken or opened by the otter. About 1 inch of the siphons appeared to have been bitten or ripped from the clam bodies. A captive otter demonstrated that clams, even large horse clams *(Schizothaerus)*, are cracked either against a

TABLE 14.—*Stomach contents of two male sea otters from Simeonof Island, Shumagin Islands, Alaska*

Specimen and food item	Volume (milliliters)	Individuals
KWK 60–6: Clam feet	2,425	155+
KWK 60–8:		
Large clam syphons	844	59
Small clam feet	206	17
Horse mussel	5	1
Whelk operculum	trace	1
Total	3,480	233

ock or against another clam resting on the otter's chest (fig. 60). t is thus inferred that clams which are buried are not dug from he bottom.

In the Bering Sea on 8 and 10 July 1960, one adult male and wo adult female otters and two pups were taken 3½ miles off the orth shore of Unimak Island in a depth of 15 fathoms and 9 miles orth of the Alaska Peninsula in 20 fathoms. The food habits of hese individuals are of particular interest because no other tomach specimens of otters which habitually remain offshore are vailable. The foods found in three of the stomachs are shown in able 15. All food items (clams, crabs, and a hexagrammid fish) re benthic forms. This indicates that here, as in other areas, the ea otter is predominantly a bottom feeder (see Diving). The lack f feces on the beaches of nearby Amak Island in July 1961 and 963 indicates that otters in this area seldom come ashore.

Fecal Analyses

Studies of sea otter food habits prior to 1962 were based rimarily on analyses of fecal remains (Williams, 1938; Murie, 940; 1959; Jones, 1951). All of these studies indicated that the ea urchin was the dominant food species.

About 95 percent of 422 fecal samples I examined at Amchitka ontained sea urchin remains (table 16). Stomach examinations, owever, as well as other studies discussed elsewhere (see Relaive Values of Sea Otter Foods), indicate strongly that mollusks nd fish are essential foods and that in some areas sea urchins nay be of relatively minor importance and then primarily during heir season of reproduction.

The examination of feces may contribute certain qualitative

ABLE 15.—*Stomach contents of three sea otters taken in 15–20 fathoms of water in the Bering Sea*

Specimen and food item	Volume (milliliters)	Individual
dult female (KWK 60–16):		
Clinocardium ciliatum	75	ca. 4
Musculus sp.?	trace	?
Surf clam (*Spisula alaskana*?)	50	1
Fish (*Hexagrammos* sp.?)	125	1
up (KWK 60–18):		
Clam, unidentified	20	ca. 4
Milk curd	10	—
dult female (KWK 60–19): [1]		
Clam (*Serripes groenlandicus*)	427	ca. 20
Tanner crab (*Chionoecetes bairdi*)	48	1
Hermit crab (*Pagurus* sp.?)	150	several
Crab, unidentified	trace	—
Musculus niger	trace	—

[1] Both stomach and intestinal contents included.

TABLE 16.—*Analysis of 422 fecal samples from Amchitka Island, Februar to April 1959*

[The samples were examined on seven habitually used hauling-out beaches]

Food organism [1]	Number of occurrences (frequency) [2]	Percent of fecal samples having item
Arthropoda:		
Crabs (Crustacea)	67	16
Mollusca:		
Chitons (Amphineura)	26	6
Snails (Gastropoda)	11	3
Limpets *Acmea*	10	3
Horse mussel *Volsella volsella*	89	21
Mussel *Mytilus edulus*	1	<1
Varnished horse mussel *Musculus vernicosa*	48	11
Pearly monia *Pododesmus macrochisma*	1	<1
Clam (Pelecypoda)	5	1
Pecten (Pelecypoda)	1	<1
Octopus (Cephalopoda)	3	1
Subtotal	195	46
Echinodermata: [3]		
Sea urchin *Strongylocentrotus drobachiensis*	401	95
Chordata:		
Fish	63	15
Total	726	----------

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[1] Nonfood material, clay, gravel, etc., was found in seven fecal samples.

[2] Frequency refers to the number of samples having the item, not the number of individual present.

[3] Starfish were probably broken into fine pieces and thus not detected.

information concerning the food habits of sea otters but, becaus hard parts of some food species are not ingested, information derived from fecal examination contributes distorted informatio on both the qualitative and quantitative aspects of food habits.

Otters must defecate on land if fecal samples are to be studied In many areas otters defecate on land infrequently or not at all Weather conditions, geographical features (such as sheltere beaches above the tide line), and the presence of a human population appear to influence the frequency with which sea otters hau out on land. Like all other marine mammals, and unlike man terrestrial ones, the sea otter is not selective in choosing a defecation site. When sleeping or resting on land, the otter usuall rises to its feet and expels the feces at the edge of its restin place. As it changes position for comfort during several hours o shore, feces may be deposited in several locations around the resting spot and the animal may, in changing position, lie in its ow feces. Defecation in the water is also a random function and ma occur while the animal is eating, swimming, or resting on its bac on the surface. Although, as noted above, defecation on land i frequent, I have often noted that captive otters, after a rest perio beside their pool, may defecate immediately upon entering th water.

Where otters habitually use certain hauling-out areas, as they do at Amchitka Island, a large number of fecal deposits may accumulate. Because these are composed primarily of the hard parts of marine organisms (fig. 66), they may remain in recognizable form for a number of weeks or, in well-protected locations, for months.

The analysis of fecal deposits from the Shumagin Islands and from Amchitka are presented in tables 16 and 17. The fact that sea urchins appeared in 95 percent of the droppings found on Amchitka and only in 4 percent of those from the Shumagins is significant. Sea urchins are available in the Shumagin Islands. It thus appears that the sea otter may feed selectively. No evidence,

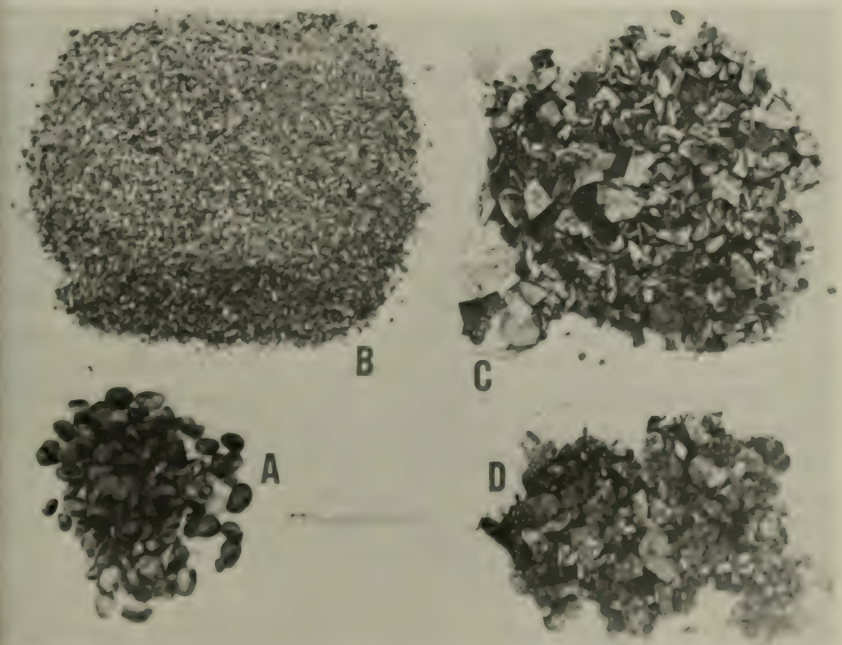

FIGURE 66.—Contents of a large (286 g. dry weight) sea otter fecal deposit: *A*—more than 100 varnished horse mussels (*Musculus*) (10 g.); these are usually swallowed whole, the viscera are digested, and the valves pass intact through the gastrointestinal tract. *B*—fragments of the tests, spines, and Aristotle's lanterns of an unknown number of green sea urchins (*Strongylocentrotus*) (159 g.). *C*—broken shells and *D*—byssus threads, of more than 40 horse mussels (*Volsella*) (117 g.). Sea urchins and large mussels are crushed by the teeth, and parts of the test or shell are swallowed. Specimen was collected on an Amchitka beach, 21 July 1956. The rule is 5 cm. (KWK 68–13–4)

TABLE 17.—*Analysis of 75 fecal samples from the Shumagin Islands*

[15 samples were taken at Simeonof Island, 5–9 June 1960 and 60 at Eagle Harbor, Nagai Island on 16 June 1960]

Food organism	Number of occurrences (frequency)	Percent of fecal samples having item
Arthropoda:		
Crabs (Crustacea)	12	16
Mollusca:		
Snails (Gastropoda)	4	5
Horse mussel *Volsella volsella*	3	4
Mussel *Mytilus edulus*	58	77
Clam (Pelecypoda)	6	8
Subtotal	71	94
Echinodermata:		
Sea urchin *Strongylocentrotus drobachiensis*	3	4
Chordata:		
Fish	8	10
Total	94	-----------

such as high winter mortality, indicates that the sea otter population has approached its maximum size in the Shumagin Islands as it has at Amchitka. It might therefore be concluded, in the light of all available evidence (see Relative Values of Sea Otter Foods), that the sea otters of Amchitka consume a large number of sea urchins because other food resources have been depleted. In areas where otter populations have not yet approached maximum size, food species more nourishing than sea urchins are still abundant and the sea urchin may be eaten to a minor degree.

The fecal analyses presented here give useful qualitative information on food habits. They show that the food habits of otters in a crowded population differ from those in areas where crowding is not a factor. It is, however, evident that stomach analyses are necessary to reveal the food habits in their proper perspective. A discussion of the method of ingestion of each group of food organisms indicates in more detail why fecal examinations are of only limited use in food habits studies of the sea otter.

Food Quantities Required

The food requirement of the sea otter is great. Captive juveniles held on Amchitka Island during the 1957-59 study periods required from 25 to 30 percent of their body weight of food per day.

The quantity of food consumed by captive adult otters did not vary according to season. The required amount for an adult male and female was similar, about 20 to 23 percent of the body weight per day. The data are discussed in the section on the sea otter "In Captivity."

Relative Values of Sea Otter Foods

Miss Neva L. Karrick, Assistant Laboratory Director, Food cience Pioneer Research Laboratory of the Bureau of Commercial isheries at Seattle, has furnished proximate analyses of certain epresentative sea otter foods (table 18). From these data and e known quantities of food consumed by captive otters and data btained from stomach examinations, it is evident that the sea rchin is seldom as important a food item as previously supposed nd that the sea otter is primarily dependent for survival on her foods with more calories and higher protein content.

A captive sea otter weighing about 40 pounds required an verage of about 8.4 lb. of food, primarily rockfish, per day (24-our period). This diet supplied about 3,400 calories (about 89 lories per 100 grams of fish). Sea urchins with gravid gonads n supply roughly 58 calories per 100 grams of gonads and 16 lories per 100 grams of viscera. If large gravid sea urchins were vailable, about 200 would be required to supply 3,000+ calories a sea otter in a 24-hour period.

Most of the sea urchins now available at Amchitka are small. he reason appears to be that a large sea otter population is over-tilizing this food resource (see Depletion of Food Resources). ature gravid green sea urchins, weighing about 115 g. each, ere obtained for analysis from an area at Cold Bay, Alaska, here there are no sea otters. At Amchitka, the size available in reatest quantity weigh about 6 to 10 g. These are consumed in rge numbers, particularly by juvenile otters. The gonads in ese immature sea urchins are almost microscopic. The amount f visceral material available in them is small and is a poor

TABLE 18.—*Proximate analysis of important sea otter food species*

verages. These data were furnished by Bureau of Commercial Fisheries Technological Laboratory, Seattle, Wash.]

Species	Moisture (percent)	Oil (percent)	Protein 6.25 × % N. (percent)	Ash (percent)	Calories per 100 grams [1]
ungeness crab meat *Cancer magister*	77.2	0.90	20.8	1.61	91
utter clam *Saxidomus nuttalli*	83.0	1.30	13.3	1.9	63
ctopus [2]	85.7	0.86	12.1	1.3	56
a urchin *Strongylocentrotus drobachiensis:*					
Gonads	85.9	2.70	8.4	2.51	58
Viscera	92.2	0.72	2.3	3.72	16
ockfish *Sebastodes* sp.	79.0	1.50	19.0	1.18	89

[1] Calories per 100 grams = average percent oil × 9 plus average percent protein × 4.

[2] Sea otters usually discard most or all of the viscera of octopus; therefore only the flesh was alyzed.

nutritional source. Because of the general depletion of invertebrates and the apparent inability of juvenile otters to obtain an adequate number of fish and mollusks, these young animals are compelled to eat the abundant and easily obtained immature sea urchins. An otter would have to consume nearly 6,500 of these immature urchins daily to supply the 3,000+ calories which appear to be required.

Depletion of Food Resources

The requirement for large amounts of food by sea otters has been discussed. Feeding grounds are limited by depth to relatively shallow waters and tag returns indicate that individual sea otters do not range widely along the coast (see Home Range). Because of these circumstances which concentrate feeding activities in rather limited areas, it appears probable that a large population of sea otters could seriously deplete food resources within their home range. Evidence is available that this does in fact occur.

SEA URCHIN DEPLETION

McLean (1962) presents convincing evidence that the sea urchin *Strongylocentrotus franciscanus* has been nearly exterminated in a particular area on the California coast which is occupied by a considerable number of sea otters. Of the area he studied he says (p. 101) "the large sea urchin was totally absent, although spines and test fragments were present in gravel samples."

Indirect evidence from Amchitka Island, where a large sea otter population exists, indicates that sea otter predation has drastically reduced certain food species there. Small green sea urchins are abundant. It is not possible, however, to find large individuals in the intertidal zone and I seldom saw an otter eating an urchin that approached in size the large individuals which are abundant in other Aleutian areas where the sea otter is scarce or absent. Bottom samples obtained by R. D. Jones, while diving with SCUBA equipment, both at Amchitka and in comparable areas at Adak (where at the time few sea otters occurred), showed that sea urchins at Amchitka are relatively scarce and small.

In a recent letter (16 December 1966), Jones reported on a subsequent visit to the Adak area he had explored prior to the time that it was occupied by a large number of sea otters:

> In 1957 the green sea urchin was numerous and obvious in this area, and this time I saw none. I have no quantitative data because I had neither the equip-

ent nor time to gather it. This same thing is reported to have happened the Sandman Reefs and Sanak Reefs when the sea otters reappeared in mbers.

John Nevzoroff, a native of the Aleutian Islands who worked ith me on Amchitka in 1962, told me that in the early 1930's, hen he trapped foxes on Amchitka with his father, sea otters ere considerably less numerous, particularly along the Bering a coast, than they are today. He also said that he found large a urchins ("sea eggs") abundant along the shores of Constantine arbor where we were unable to find them in the 1955–63 study riod.

Tons of fragments of large sea urchin tests are contained in tchen middens at Amchitka Island. These indicate that in prestoric times large sea urchins were abundant there. Presumably e aboriginal human population was able to obtain these large a urchins because the sea otter population had been utilized and duced. Thus, the sea urchin resource was not overexploited by e otters as it is today, and the urchins were allowed to grow to aximum size.

It is evident that at Amchitka, where mature sea urchins are arce, the diet of the sea otter must be supplemented by other ods, such as fish and mollusks, to prevent starvation. That arvation does, in fact, occur in winter and early spring, partic- arly among young otters, is discussed in the section on Limiting actors.

HE ABALONE–SEA OTTER PROBLEM N CALIFORNIA

J. H. McLean writes (letter, December 1964):

> miles of coastline below San Simeon which formerly produced abalone year ter year under continuous commercial exploitation has been completely ined for abalone as a result of the southern migration of the California rds. It has nothing to do with the number of divers now working because e otters take the entire population, not just those of legal size. The fact that otters, urchins and abalones do not coexist and the entire commercial alone fishery is very seriously threatened by possible southern expansion range.

Cox (1962), who has conducted comprehensive studies of the alone (*Haliotis*) along the California coast, says (p. 57) "all idence indicates they [sea otters] pose a threat to human exoitation [of the abalone] when the two are competing in the me area." Data gathered in Carmel Cove and Stillwater Cove fore and after the areas were occupied by sea otters demonstrated that the local abalone beds were seriously decimated but not entirely eliminated by sea otter predation.

In a public statement, additional information was given by Cox (California Senate, 1963):

> In 1956 we went into Shelter Cove right off Monterey and over a period of several days tagged 513 abalone. One year later we came back in the area and we spent approximately three days searching and we found five abalone . . . one of which had a tag. The area where we were able to collect five hundred abalone in an hour we couldn't find any. On one dive I brought up over two dozen broken shells . . . characteristic of broken ones of the sea otters. We were told . . . by the caretaker, that a herd of sea otters had spent the winter in this cove . . . I had been called to task for not reporting this. . . . However, I felt this was not an adequate experiment.

In a recent study of sea otter feeding habits on the California coast, Ebert (1968) concluded that "sea otters exert a profound influence upon benthic communities."

During 1963, abalone fishermen in San Luis Obispo County, California, complained that sea otters were destroying the abalone resource of that area. Claims of spectacular damage to abalone beds appeared in many newspapers. In response to these complaints a hearing was held at the City Hall, San Luis Obispo, on 19 November 1963. At this hearing Mr. Harry Anderson, Deputy Director of the California Department of Fish and Game, presented testimony to the California Senate Fact Finding Committee on Natural Resources. He compared commercial landings of abalones in certain areas before and after sea otters were present in these areas. In 1961 when sea otters were present "the catch was over 1,550,000 pounds, by far the largest catch of any year in the 10-year period." He indicated further that competition among abalone fishermen has increased greatly. In 1928 there were 11 licensed commercial abalone fishermen in California. The number has increased to 505 in 1963. Since the abalone resource is limited, it becomes apparent that the individual fishermen can expect to obtain fewer abalones than when competition among them was less. It was concluded that "all the evidence we have indicates that the sea otter has not seriously harmed or threatened the abalone resource."

The data indicate that the depletion of food resources at Amchitka has resulted in an abnormally high winter die-off of sea otters as well as a population of undersized animals (see Mortality Factors and Body Measurements). Evidence from California reveals that when sea otters feed for an extended period in a limited area they may seriously deplete local populations of their prey species.

Unusual Food Items

BIRDS

On 27 March 1962, at Amchitka Island, I watched an adult female sea otter through a 50-power telescope while she consumed what appeared to be a shearwater *(Puffinus)* or Fulmar *(Fulmarus)*. When first seen she was carrying the carcass on her chest. She stopped in the shelter of an islet to groom, leaving the bird floating beside her. After about 5 minutes of grooming she picked up the bird and tore flesh from the breast. She alternately groomed and ate for about 30 minutes. While she ate, the bird's intestines streamed out across her chest and feathers littered the water around her. After apparently satisfying her appetite she swam away carrying the carcass, bloody sternum erect, on her chest.

On 13 November 1957, I found sea otter feces at East Cape, Amchitka Island, which consisted of feathers, skin, fat, and flesh (breast muscle) of what appeared to be a cormorant *(Phalacrocorax pelagicus)*. The chunks which were torn from the bird showed little indication of having been affected by passage through the digestive tract.

Hungry captive otters consumed Emperor Goose *(Philacte canagica)* flesh (Kirkpatrick et al., 1955) but Jones told me that the meat passed undigested through the alimentary tract.

It appears that the flesh of birds is eaten only under the stress of hunger, particularly in winter. Also, the sea otter, adjusted to a diet of fish and invertebrates, seems unable to derive nourishment from the flesh of birds.

MISCELLANEOUS

On several occasions sea otters were seen to eat unusual food items that zoo visitors threw into their pool. These included a slice of white bread, a marshmallow, and peanuts. The animals appeared to suffer no ill effects from ingesting these items but the keeper reported that the peanuts passed through the animal undigested.

Conclusions

It is evident that fecal examinations give less adequate information about sea otter food habits than similar studies for other species. Certain food species (clams and certain fishes) may not appear in recognizable form at all in droppings because shells are not swallowed and the bones of some fish *(Cyclopterichthys)* are soft and are digested. On the other hand, when sea urchins are eaten some part or all of the test may be swallowed. The important quantities of high protein food contained in mollusks and fish cannot be evaluated by the examination of feces.

It has been wrongly assumed that sea urchins held first-rank importance as a sea otter food. Barabash-Nikiforov (1947) believed that sea urchins were essential to survival. There can be no question but that where and when mature gravid sea urchins are available they are an important food source. That they are not essential to sea otter existence is demonstrated by: (1) A captive sea otter was given no sea urchins for a period of 4 years and remained in good health; (2) numerous captives held on Amchitka refused to eat urchins after being introduced to a diet of fish; (3) each winter many juvenile sea otters (apparently incapable of obtaining fishes) died of enteritis (probably induced by shock or stress accompanying starvation) and were found to have the remains of considerable numbers of sea urchins in the intestines; (4) feces and stomachs of sea otters taken, for example, in the Shumagin Islands, contained few, if any, sea urchin remains (although sea urchins occur there).

My conclusion is that sea urchins may, during their season of reproduction in areas of abundance, rank high in importance as a sea otter food source. Where an abundance of mollusks and fish may be obtained, however, the sea urchin is at no time an essential food species. The food value of the sea urchin may vary from poor to good, depending on maturity and the season of reproduction. Mollusks and fish, however, when available and to those animals able to obtain them, furnish an adequate and consistently nourishing diet. Mollusks (37 percent) and fish (50 percent), relatively high in calories, account for 87 percent by volume of the sea otters' food at Amchitka.

DISTRIBUTION AND NUMBERS

Original

The sea otter originally ranged at least as far south as Morro Hermoso (27°32′ N. lat.) on the Pacific Coast of Lower California Ogden, 1941, p. 7). Scammon (1870) noted that it occurred at edros Island, about 30 miles north of Morro Hermoso, and at uadalupe. From these locations its distribution continued northward along the coast of North America to Prince William Sound nd westward through the Aleutian, Pribilof, and Commander slands to the coast of Kamchatka and south through the Kuril slands at least to northern Hokkaido and southern Sakhalin Barabash-Nikiforov, 1947) (see map, fig. 67).

CE AND THE NORTHERN LIMIT OF RANGE

The northernmost permanent sea otter population in the Western emisphere is in Prince William Sound (60°30′ N. lat.) where e sea does not freeze. In the Bering Sea the aboriginal population n the Pribilof Islands (57° N. lat.) and that along the northwest xtremity of the Alaska Peninsula (55° N. lat.) overlap the southrn limit of winter drift ice. That the sea otter is able to survive mited winter ice conditions is also indicated by the fact that the boriginal Pribilof population was apparently a large and permannt one, and that on occasion the sea freezes there for brief periods. Winter drift ice reaches the southeastern Kamchatka coast and Kuril Islands where early sea otter populations were apparently rosperous and are today increasing. Nikolaev (1965b) found in he Kuril Islands that when sea otters were unable to move to iceree locations in winter they died of starvation. When closed in y ice they crossed its surface or even went overland in search of pen water.

Bee and Hall (1956) record two unsubstantiated sight records f sea otters far north of their usual range in the Arctic Ocean. ne was reported in 1951 at Cape Halkett, 70°49′ N. lat., 142°16′ W. long. and another at Atigaru Point, 70°35′ N. lat., 151°50′ W. long. C. H. Fiscus, who obtained these reports from other obervers, told me in 1964 that he is now doubtful of their authenicity.

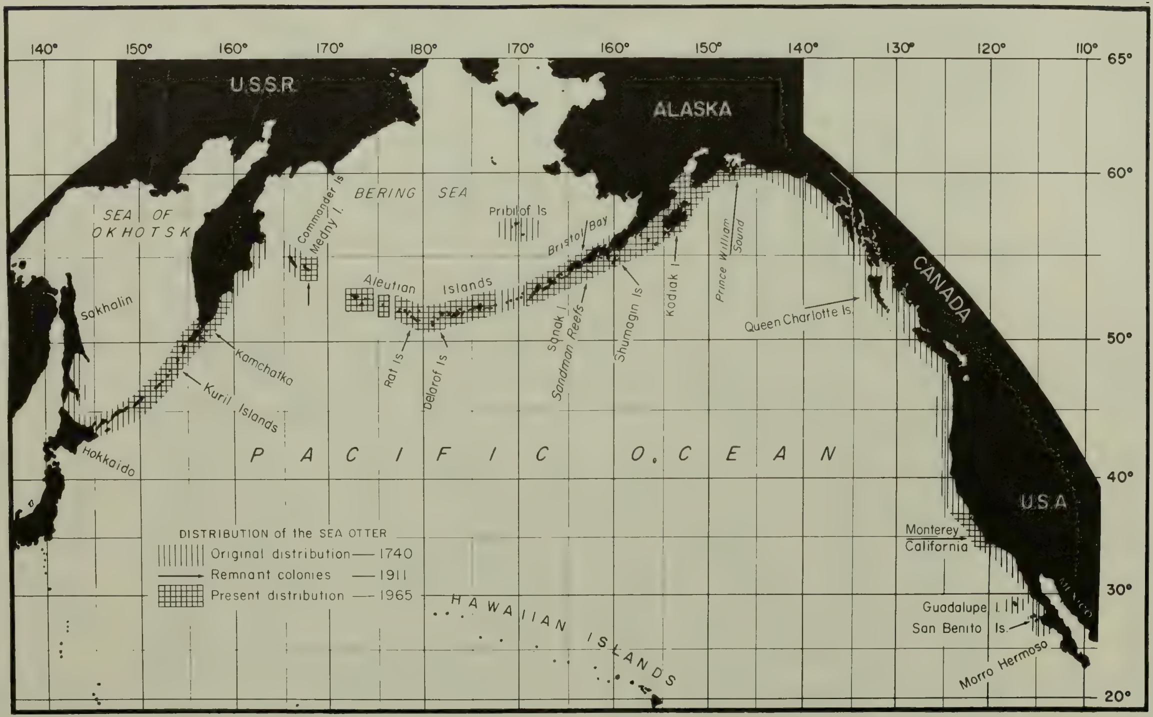

FIGURE 67.—Distribution of the sea otter in 1741 and 1965, also showing the locations where remnant colonies survived in 1911 when protection was given. Two of these known remnant colonies, in the Queen Charlotte and San Benito Islands, were exterminated by 1920.

Barabash-Nikiforov (1947) and Nikolaev (1960) indicate that on the east coast of Siberia the sea otter may have ranged to 64° N. The records, however, are vague. Gulin (1952) photographed the skin of a sea otter said to have been taken by local hunters at Lavrentiya (65°08′ N. lat., 171° E. long.) near Bering Strait on the Chukotsk Peninsula. No date or other specific data are given. Such a casual report in a popular magazine of a sea otter so far north of the usual range must be regarded with skepticism.

Specific records as far north as 64° do not appear to be available. Gribkov (1963) says that the known boundary of the sea otter's range is 57° N. on the east coast of Kamchatka but mentions that in 1960 sea otters "were bagged" north of this point.

The occurrence of a permanent sea otter population in the northern Bering Sea or Arctic Ocean where the sea freezes is quite unlikely. That a stray otter might have traveled north with pack ice in spring from the lower limit of winter drift ice in southern Bristol Bay and the southeastern shore of Kamchatka, is a possibility. Retreating winter ice might account for the presence of three sea otters at the Pribilofs in 1889, 1892, and 1896 (Preble and McAtee, 1923) long after they were extirpated there. A sighting in Norton Sound (64° N.) in June 1941, was reported by Frank Glaser (*in* Lensink, 1958).

In general it is true today, as it was in early times, that the prosperous sea otter colonies are south of areas where sea ice forms regularly and remains for long periods in winter months.

The environmental factors that control the southern limit of distribution, other than predation by man and environmental pollution caused by him today, are unknown. Additional sources of information on aboriginal distribution are cited by Barabash-Nikiforov (1947).

POPULATION REDUCTION THROUGH EXPLOITATION

Intensive exploitation of the sea otter by Europeans began with the voyage of Vitus Bering in 1741 and continued unregulated for 170 years. Exploitation was halted and protection was given to the sea otter by international treaty in 1911.[3]

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[3] Convention between the United States, Great Britain, Russia, and Japan for the preservation and protection of fur seals. Proclaimed 14 December 1911 and approved 24 August 1912. Article V of this Convention extended protection to the sea otter. Further protection was extended by the "Presidential Proclamation for the preservation and protection of fur seals and sea otter," signed by Woodrow Wilson on 31 May 1913, and an "Executive order regarding the protection of fur seals and sea otters," signed by Calvin Coolidge on 14 January 1929 (U.S. Bureau of Fisheries, 1929).

The sea otter was then commercially extinct and nearly extinct as a species. The number of sea otters that were taken during the period of unregulated exploitation is not known because proper records were not kept. Most records are vague concerning where skins came from, except that they came from the New World. Fisher (1940b) states that her summary is not complete but lists records of 359,375 skins taken between 1740 and 1916. Between 1745 and 1867, "260,790 sea otter skins were reported as having been shipped from Alaska" and from 1868 to 1905 the take was 107,121 skins (U.S. Bureau of Fisheries, 1906). From 1906 to 1910, 240 skins are recorded taken by U.S. and Canadian hunters (U.S. Bureau of Fisheries, 1907 through 1911). Thus the total recorded number of skins taken in waters off Alaska, prior to 1911, was 368,151. Skins taken by hunters of other nationalities are not recorded. Lensink (1960) presents figures and broad estimates which place the take of sea otters from Alaska at over 906,500 animals.

POSTULATED SIZE OF ABORIGINAL POPULATION

From data gathered during recent studies, some idea of the possible take may be postulated. Today it appears that about 30,000 sea otters occupy approximately one-fifth of the original lineal coastal range of the sea otter. Some of the presently occupied habitat is of superior quality. Islands contribute more usable habitat than do unbroken continental coastlines. Thus, it is probable that the population of sea otters in 1740 may have been no more than five times the present number, probably between 100,000 and 150,000 animals. If the annual increment that could be cropped on a sustained yield basis was about 2.5 percent per year (the approximate annual yield of the Pribilof fur seal *(Callorhinus ursinus)* herd is 5 percent per year and fur seals normally bear one pup each year; 2 years elapse between sea otter pups), then the take in 170 years could have been between 425,000 and 637,500 if cropping had been rational. The killing of sea otters, however, was unregulated and for periods of many years the take was at the expense of the population "capital." Probably certain populations were wiped out during an early part of the exploitation period. Thus the yield over the entire period was less than it would have been if only the annual increment had been taken. Reasoning on this basis, it appears that the probable take of sea otters between 1740 and 1911 was less than a million and more likely about a half million animals.

In the following section, sea otter population studies in Alaska are reviewed and a summary of information on the past and present world populations is presented. Field counts of living sea otters (omitting pups carried by mothers) furnish the information on which this study of population and distribution is based. To obtain a knowledge of population dynamics, studies of mortality, reproduction, food habits, and movements of sea otters were also undertaken.

Modern

ALASKA POPULATIONS

The greatest population of sea otters in the world today is in the central to outer Aleutian Islands (table 36). This is also the area where repopulation of available habitat, from which the sea otter was extirpated before 1911, is apparently occurring the most rapidly. It is also the location where most of our studies were concentrated.

Data were made available by individuals who visited or worked in Alaska during the 1930's and 1940's. Additional data were obtained, particularly after 1955, by observers who made extensive aerial and surface surveys. During these studies, areas occupied by sea otters as well as areas to which otters have not yet returned were surveyed.

The Aleutian Islands chain consists of five named groups of islands from west to east (subgroups are in parentheses): the Near (Semichi Islands), Rat, Andreanof Islands (Delarof Islands), the Islands of Four Mountains, and Fox Islands (Krenitzin Islands) (see map, fig. 68). Important island groups which furnish suitable sea otter habitat are separated from each other by passes up to 55 miles wide, hundreds of fathoms deep, and swept by swift tidal currents. These wide passes appear to hinder seriously the movements of otters from a heavily populated area to a neighboring island group having vacant habitat.

Today (1968), a sea otter "population explosion" is occurring in the Andreanof Islands. The early expansion of this population was sketchily documented during the late 1930's and early 1940's. More thorough observations were made in the 1950's and until 1965. A similar "population explosion" in the Rat Islands apparently reached a climax in the mid-1940's. The historical data on these two populations are reviewed below and compared with modern findings.

The locations in which sea otters survived the 1741–1911 period

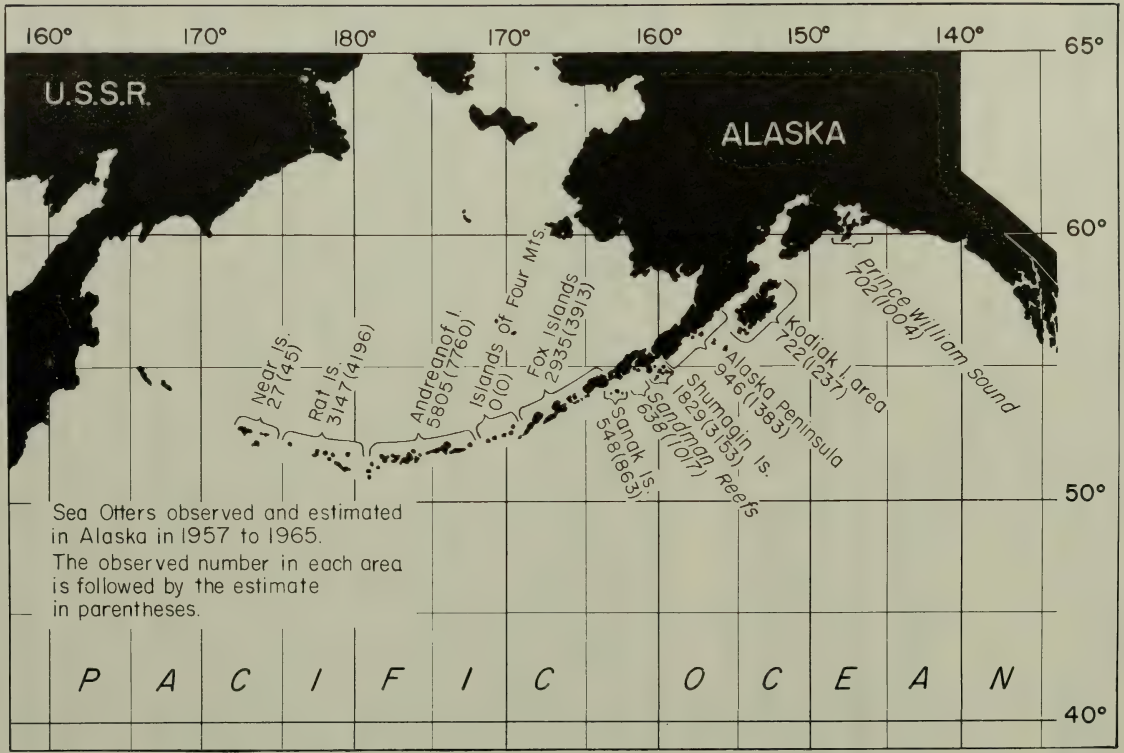


FIGURE 68.—Beginning in 1957, aerial surveys of sea otter habitat were undertaken (see appendix 1). From the recorded counts of otters, calculated estimates of the various populations were derived. Because the figures on this map were taken from tables in the text, they are not rounded.

f unregulated hunting are indicated by (1) areas where large opulations are found today, and (2) areas where sea otters were taken shortly before and after 1911. Fragmentary data on otters that were taken between 1906 and 1936 are reviewed briefly elow.

Records of the U.S. Bureau of Fisheries (1907–37) indicate that t least 302 otters were taken in Alaska from 1906 through 1936. f these, 240 were taken between 1906 and 1911 and 62 from 912 to 1936. For 213 skins (186 before 1911 and 27 after 1911) o location of origin is given, but many apparently came from the Aleutian, Sanak, and Kodiak Islands areas. The specific locations f origin of the remaining skins were often not stated clearly. It ppears, however, that the remaining 89 skins may be allocated to the following areas: Aleutians, 7 (4 in 1910 and 3 in 1929); outhern Bristol Bay and Bering Sea north of Unimak Island, 15 all before 1911); Alaska Peninsula, south coast (about 56° N.), (1918, 2; 1929, 2; 1931, 2); Sanak Island area, 3 (1926, 2; 934, 1); Shumagin Islands, 1 (1910); Kodiak area, 52 (31 before 911 and 21 after 1911); Prince William Sound and Kayak Island rea, 5 (1910, 3; 1924, 2). Within these areas otters probably urvived along exposed coasts that offered few if any anchorages nd where offshore reefs made hunting hazardous. Such areas lso offered otters feeding habitat well offshore.

The map (fig. 68) and table 19 summarize modern field counts nd estimates of sea otter populations in Alaska and indicate that most of the population is concentrated in an area about 500 miles ong which includes the Rat and part of the Andreanof Islands 9,605 observed, 1965, table 19). From the present spearhead of opulation expansion in the central Andreanofs eastward to the ext small colony at Atka (228 observed, 1965, table 25) is about 5 miles. The next colony (159 observed, 1965, table 25) is 50 miles farther east, near the east end of Amlia. Moving eastward 0 miles, the next colony (28 observed, 1965, table 25) is at eguam. From here to the small Samalga-Umnak colony (9 observed, 1965, table 30) is 140 miles. The next small colony (32 bserved, 1965, table 30) is at Tigalda Island 175 miles to the east. From here to the Unimak–Amak–Port Moller colony (2,892 observed, 1965, table 30) is 75 miles. Along the south side of the Alaska Peninsula and northeastward to the Kayak Island area, a istance of about 800 miles, the colonies (5,748 observed, table 36) re not separated by any known geographic barriers.

After the publication of population and distribution studies by Lensink (1960) considerable field work was undertaken. The data

TABLE 19.—*Summary of sea otters observed and estimated in Alaska*

[See tables in sections for counts by islands. Most areas have now been surveyed several times. The highest counts which were made under optimum conditions were selected for this summary. Three observers, D. L. Spencer, C. J. Lensink, and K. W. Kenyon gathered most of these data]

Area	Aerial surveys		Estimated total otters [1]	Estimated total 1965 [2]
	Year	Otters observed		
Near Islands	1965	27	45	45
Rat Islands	1965	[3] 3,147	4,196	4,196
Delarof Island	1965	[3] 653	871	871
Andreanof Island	1965	[3] 5,805	7,760	7,760
Islands of the Four Mountains	1965	0	0	0
Fox Islands	1965	2,935	3,913	3,913
Bogoslof Island	1962	0	0	0
Sandman Reefs	1962	638	879	1,017
Sanak Island area	1962	548	746	863
Shumagin Islands	1957	1,829	2,724	3,153
Pavlov Islands	1962	4	8	12
Alaska Peninsula	1962	949	1,317	1,383
Semidi Islands	1957	5	10	12
Kodiak area	1957–59	722	973	1,237
Prince William Sound and Kayak Island	1959	702	1,004	1,004
Total		17,964	24,446	25,466

[1] See Aerial Surveys for method of estimating.
[2] Projected in the regions where growth was observed on the assumption that the increase is at the rate of 5 percent per year.
[3] Total 9,605.

now available indicate that in significant areas sea otter populations have declined and are less than the estimates which Lensink computed on the basis of figures then available to him. Lensink (1960) considered that sea otter feeding habitat included waters to a depth of 50 fathoms, but no evidence is available that they descend to this depth (see Diving). Because of this assumption a greater area of available habitat and greater population potential was postulated by Lensink than is indicated by information now available. Also, Lensink's (1960) estimates for a large sea otter population at Amchitka do not agree with the modern or historical data for this area. The rate of population growth which he postulated is greater than indicated by the data now available. In addition, as shown later, the Amchitka population "crashed" in the 1940's and now fluctuates annually near a population about one-half its maximum size.

Aerial surveys

The most extensive aerial surveys consumed about 200 hours of flight time in a DC–3 aircraft (table 20). Air speed was maintained at 120 knots and flight altitude varied from 200 to 400 feet, depending on winds and nearby terrain. Two observers counted otters from the aircraft's cockpit. Some groups were so large that

TABLE 20.—*Summary of aerial surveys of sea otters, 1957–65*

[Before these surveys, organized surveys were not undertaken]

Date	Method	Hours of flight time	Observers	Areas surveyed (inclusive)
1957: 6 May–28 Sept.	A variety of air and surface craft used	(?)	C. J. Lensink, D. L. Spencer, R. D. Jones, W. A. Troyer, F. Wilke	Various areas, Cook Inlet to Kanaga Island (Aleutians).
1958: August	Aircraft	(?)	W. A. Troyer	Shuyak area.
1959:				
21–27 May	DC–3 aircraft	56.8	D. L. Spencer, K. W. Kenyon	Attu Island (Near Island group) to Herbert Island (Island of Four Mountains).
13 July	UF–2 aircraft (U.S. Coast Guard)	3	K. W. Kenyon	Outer coast, Olympic Peninsula, Washington.
July	Aircraft	(?)	C. J. Lensink	Kodiak area.
August	Cessna 180 aircraft	(?)	C. J. Lensink, R. Pirtle	Prince William Sound, Kayak-Wingham Island.
1960: 3–5 March	DC–3 aircraft	28	D. L. Spencer, K. W. Kenyon, D. W. Rice	Herbert Island to Amak Island.
1961:				
27 March	DC–3 aircraft	4	D. L. Spencer, K. W. Kenyon	Amak area (failed because of fog).
27 October	UF–2 aircraft (U.S. Navy)	1.8	L. W. Croxton, K. W. Kenyon	Adak area (all data lost in crash of survey aircraft).
1962: 29 March–10 April	DC–3 aircraft	53.6	D. L. Spencer, K. W. Kenyon, J. J. Burns	Rat Islands to Amak I.; Sanak, Sandman Reefs, Shumagin Is., Alaska Peninsula.
1965: 19 April–9 May	DC–3 aircraft	49.2	D. L. Spencer, K. W. Kenyon, E. G. Klinkhart	Aleutian Is., Alaska Peninsula (part), Cook Inlet (part).
Total		196.4+		

all individuals could not be counted in the time available. In such groups we counted a sample of 10 to 50 animals. We then visually divided the remainder of the group into sectors equivalent to the counted sector to obtain an estimate of the total number of animals. Aerial photographs were taken of unusually large groups to ascertain the accuracy of the field estimates (see Aerial Photography). The flight path was divided at the center line of the aircraft. One observer stood behind the pilot and the other behind the copilot. Otters were seen to a distance of at least 1 mile on each side of the aircraft during excellent survey conditions and to at least ½ mile under good conditions.

The width of the survey track was ascertained by flying at survey height over an air strip of known length. In this way each observer obtained a reference point on the wing of the aircraft, which from his position in the aircraft during surveys delimited a known distance on the surface.

Observation conditions were evaluated during the surveys and were classified as follows:

Excellent—no wind, high overcast (water glassy and no glare).

Good—light wind (to 6 or 8 knots) and overcast; or no wind (glassy water) but sun glare present.

Fair—light wind to 10 knots and surface glare or wind 8 to 15 knots and sky overcast.

Poor—winds over 10 knots and glare on water, or wind over 15 knots regardless of sky cover.

When possible, survey operations were suspended during fair or poor conditions, because too few otters could be seen and the errors in the census could not be properly evaluated.

Observations were recorded by one of the biologists, or by a third person assisting him. Each observation was immediately plotted on a U.S. Coast and Geodetic Survey chart.

Several aerial surveys which supplemented the comprehensive surveys were conducted from single engine aircraft and from a Grumman Widgeon. Also, the U.S. Navy cooperated by sending Fish and Wildlife observers on survey flights in a UF–2 Grumman Albatross aircraft.

Data were gathered in 1959 to provide a factor for computing estimated total sea otter populations from aerial counts.

In an effort to ascertain as nearly as possible the number of sea otters occupying a particular coastal area at Amchitka Island, inshore and offshore surface surveys were repeatedly conducted by dory. A total of 17 survey counts were made along a 13-mile section of coast from (and including) Crown Reefer Point

51°28′ N. lat., 179°11′ E. long,) to (but not including) East ape (51°22′32″ N. lat., 179°27′45″ E. long.) The surveys were onducted in February, March, and April of 1959 (see Kenyon and pencer, 1960).

These surface surveys differ from the others because an inten-ive effort was made in a limited area to observe, by repeated trips, he available sea otter habitat at close range in locations familiar o the observer. The mean number of otters observed was 254. On n aerial survey of the same section of coast in May 1959, 192 tters were counted. Thus, approximately 76 percent of the number een from the surface was observed from the air.

If only the highest surface counts for the section of the coast re considered, the total count for the area is 295 otters. This igure would indicate that on the aerial survey about 65 percent f the otters in the survey area were seen $(\frac{192\times100}{295})$.

Based on the premise that the maximum number of otters seen n surface surveys failed by 15 percent to include all those present, n aerial survey would reveal 50 percent of the otters present. This orrection factor was used previously (Kenyon and Spencer, 1960).

The correction factor indicating that about 75 percent of the tters were seen is a conservative one and is used to estimate total opulations in the following discussion for these reasons: (1) Tag ecoveries at Amchitka revealed that the home range of a sea otter nay include about 10 miles of coastline. It therefore appeared easonable to use the mean of counts for each part of the area tudied. In this way some compensation is made for the movements f individual otters in and out of the study areas during intervals etween surveys. (2) Many observations during aerial surveys, vhen the same locations were flown over repeatedly, indicated to is that, in general, under excellent conditions we saw at least 75 ercent of the otters present. In some places, having a minimum umber of rocks and kelp breaking the surface, where the shore-ine was even and the band of water furnishing available feeding abitat was narrow, we felt reasonably certain that, in calm veather, we saw more than 75 percent of the otters present. 3) We found that water depths as shown on USCGS charts con-tituted a dependable guide to locations inhabited by sea otters. large majority occur within the 20-fathom curve (waters less han 120 feet in depth). Rarely do sea otters occur in water as leep as 30 fathoms. Therefore we consider that no significant umber of sea otters was missed during the aerial surveys.

Future studies may show that we were unable to estimate the error in our counts accurately. Nevertheless, the results of the surveys are comparable and they establish the order of magnitude of populations in the locations that were surveyed. For the purpose of this report, comparability of field observations in different areas is more important than an estimate of absolute population magnitude.

On calm days, when the sea was glassy and a floating otter could be seen at a distance of more than a mile on each side of the aircraft, we carefully examined many extensive offshore areas between islands. Where the water is shallow and otters occur in numbers well offshore (as off the north shore of Unimak Island) we systematically flew sectors through the area covering most of the sea's surface where otters occurred.

In areas of dense population, the otters tend to gather in groups or "pods" of variable size numbering from 10 to 30 animals. Groups of 100 or more animals were infrequent (fig. 69) and rarely were more than 200 otters together (the maximum observed was 440, fig. 70). In sparse populations, relatively fewer groups

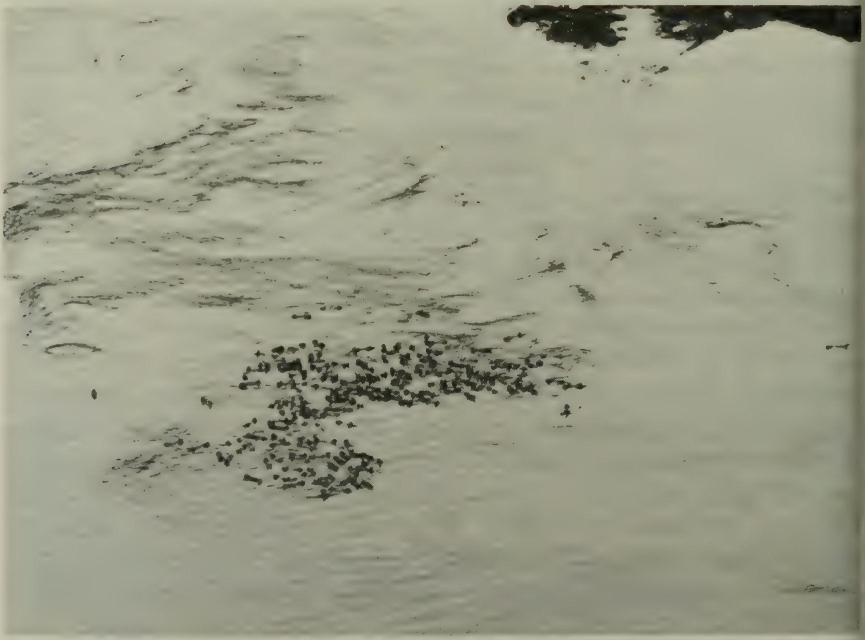
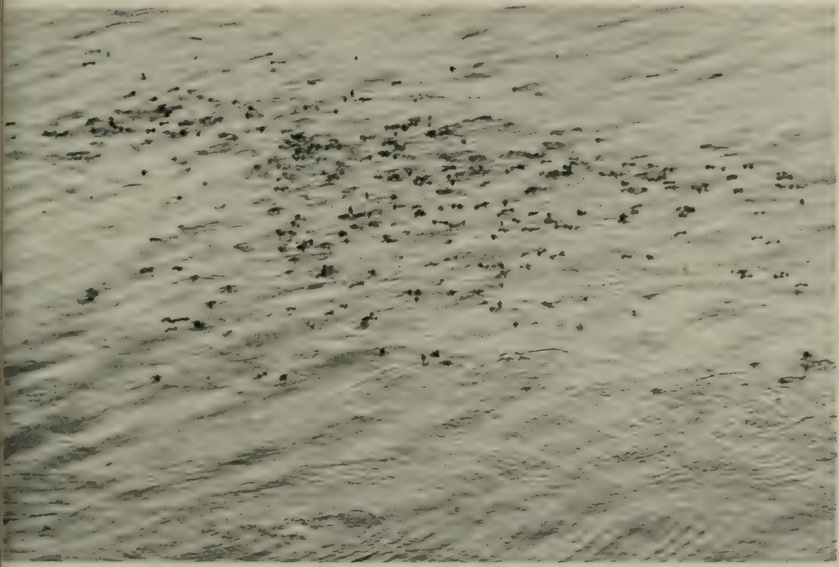


FIGURE 69.—A group of 157 sea otters resting in a kelp bed in Kagalaska Strait (between Adak and Kagalaska Islands), Aleutian Islands, Alaska. Flight altitude about 150 feet, air speed 120 knots; 6 April 1962. (KWK 62-35-19)



IGURE 70.—Part of a group of 440 sea otters in Kujulik Bay on the south shore of the Alaska Peninsula. This was the largest group observed on the aerial surveys. Flight altitude 200 feet, air speed 120 knots; 10 April 1962. (KWK 62–39–13)

f animals were seen; most animals were scattered. Because it s easier to see a large group of animals than scattered individuals, e realized that, in our aerial surveys, we saw a greater proportion f the animals where populations were dense than where they ere sparse. For this reason, a sliding scale based on numerous eld observations was chosen to compute an estimate of total opulations in various areas.

Otters counted	*Estimation factor to obtain total*
1-15	Estimate 50 percent were seen
16-100	Estimate 60 percent were seen
Over 100	Estimate 75 percent were seen

erial photography

Aerial photography is a useful censusing tool when views of nimal concentrations may be obtained. A large majority of sea tters are scattered as individuals or gathered in small groups of to 20 animals, which may be counted directly. Therefore we ave used aerial photographs primarily to assist us in improving ur technique of estimating occasional large concentrations of tters. The mean of 1962 and 1965 data listed below shows that the field estimates of large concentrations were 12 percent below the number counted on photographs. The 1965 field estimates, made after studying earlier results, however, averaged only about 2 percent below the counts from photographs. Relatively few groups as large as 100 animals were seen, therefore no general correction factor is applied to the field count, as this would not materially affect the overall estimate.

Date	Location	Field estimate	Photo count	Percent error in field estimate	
6 Apr. 1962	Kagalaska Str.	150	157	—5.	—36.
10 Apr. 1962	Kujulik Bay	250	387	—35.	
25 Apr. 1965	L. Tanaga I.	300	334	—11.0	—2.
25 Apr. 1965	Umak I.	275	274	+0.4	
25 Apr. 1965	Box I.	450	440	+2.0	
Total		1,425	1,592	[1] 12.	

[1] Average.

Surface surveys

Surface surveys were made in limited areas from an outboard motor-driven dory and by observers using binoculars and telescope from shore (Lensink, 1958; Kenyon and Spencer, 1960).

A review of observations of sea otters from 1933 through 1962 in many Alaska areas indicates that observations of numbers of animals made from the surface are generally less useful than aerial observations. When a local otter population is small, surface observers may miss the animals altogether. For example, on aerial surveys in 1959, 1962, and 1965 Spencer and I were able to count 8 to 10 otters in the vicinity of Samalga Island and Cape Sagak, Umnak Island. Reports from Aleut hunters at nearby Nikolski Village during the past 10 years indicate that this population, though small, is permanent. In 1961, R. Thomas and in 1963, G. Baines, fur seal research biologists, Bureau of Commercial Fisheries, visited Samalga. They each spent a 24-hour period on or near Samalga and looked specifically for sea otters. Neither saw otters or any indication on beaches that they were present.

Lensink (1958) counted otters in the Shuyak and Barren Islands in the summer of 1957, first from the surface and then from the air. The surface count was 211 otters. On an aerial survey of the same area he recorded 515 otters, indicating that at least 59 percent of the otters in an area may be missed on a surface survey. On the basis of these surveys, a correction factor of 60 percent is applied to certain surface counts that are discussed.

Area of habitat

Sea otter feeding habitat was ascertained to consist of waters

0 fathoms or less in depth (see Diving). Where population and istribution surveys were made, the area of available habitat was easured on U.S. Coast and Geodetic Survey charts. A modified creage grid, 64 dots per square inch, was used to obtain measure- ents which were converted to square miles of available habitat. stimates of populations (exclusive of pups carried by mothers) ere applied to the square miles of habitat to obtain the population ensities that are presented in the following discussion and tables.

The entire Aleutian Chain, waters adjacent to the Alaska eninsula, the Sanak Islands and Sanak Reef area, the Sandman eefs, and the Shumagin Islands were surveyed one or more times nder good to excellent observation conditions during our com- rehensive 1959, 1960, 1962, and 1965 surveys. During these rveys and those by other individuals in different Alaska areas, 7,964 (table 19) otters were observed. The highest count obtained each area surveyed was used to obtain this total.

As the aerial surveys and surface studies proceeded, it became vident that the population of sea otters in the various geographi- ally separated areas exhibited different stages of population evelopment. For example, in the Rat and Delarof Islands a rowded population heavily exploited available food resources (see ood and Feeding Behavior), and in certain of the Andreanof slands dense local populations were expanding into adjacent areas f vacant habitat. These observations are discussed in the per- ective of available data from earlier observers under the geo- raphical headings that follow.

he Near Islands

This Aleutian group (fig. 71), the western extremity of U.S. rritory, is separated from Buldir, the westernmost of the Rat lands by 55 miles of open water. Attu and Agattu are the largest lands but Shemya is today more important because of its airfield nd military base. A small military base has been maintained on ttu since World War II. Early in the war, the native Aleut pop- ation was removed from Attu by the Japanese and was never established there (Golodoff, 1966).

In the early years of sea otter exploitation, the Near Islands ielded many furs. The Alaska survey expedition of the U.S. Navy epartment in 1932 searched for sea otters at Attu but found none. nformation was received, however, that "the Chief of the Attu atives assured the commander of the expedition that there were few [sea otters] at Agattu which would soon be gone because e Japanese come frequently to take them" (Hutchinson, 1935).

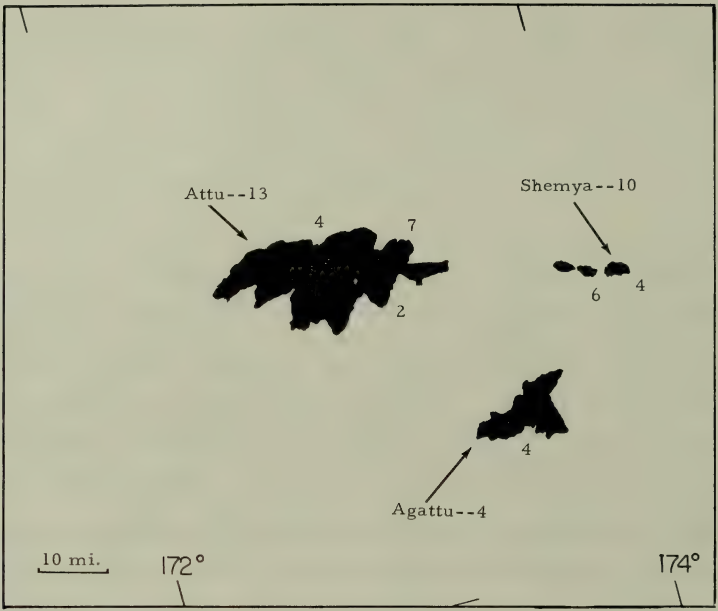


FIGURE 71.—The sea otter was exterminated from the Near Islands during the late 1800's or early 1900's. Probably because wide passes separate these islands from the heavily populated Rat Islands, it was not until July 1964 that the first authentic observations of otters were obtained in the Near Islands. Our aerial survey of 2 May 1965 revealed that at least 27 otters are now established there.

Whether the remnant population was exterminated before 1911, or by poaching in later years, is not known. Beals (1943) visited the Near Islands but was unable to find any clue that the sea otter existed there. That the aboriginal sea otter population of the Near Islands was in fact extirpated is beyond doubt.

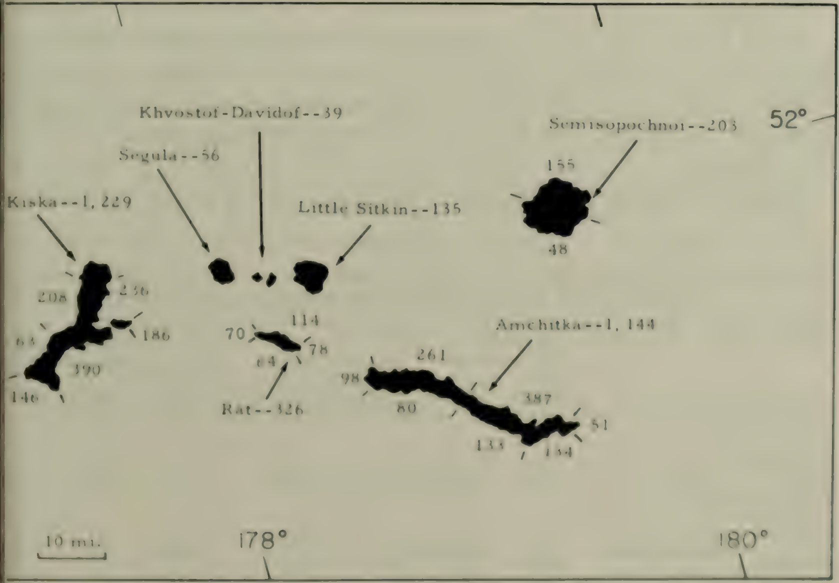
In 1956, Refuge Manager R. D. Jones moved five otters to Attu from Amchitka on a U.S. Navy ship and liberated them. It is not known whether any of these survived. Before our 1959 aerial survey, no surface observer had reported seeing otters.

Our aerial survey of 19 May 1959 included all of the Near Islands and was conducted under excellent conditions. We made repeated sweeps to inspect areas appearing to offer ideal sea otter habitat but we saw no sea otters.

B. F. Jones, while a biologist with the Fisheries Research Institute, told me that on 12 June 1959 he sighted one otter one-fourth of a mile off Chirikof Point at the eastern extremity of Attu. An additional report from R. D. Jones (letter, 25 March 1964) states at a warrant officer stationed at Shemya "is convinced he has en a sea otter several times" there. In July 1964, R. D. Jones 965) saw eight otters in the Near Islands and obtained skeletal mains of another at Agattu. On an aerial survey, 2 May 1965, e saw 13 otters at Attu, 4 at Agattu, and 10 at Shemya. These servations indicate that the Near Islands population is now tablished. The Near Islands were probably repopulated by otters om the heavily populated Rat Islands. The statement by Nikolaev 960) that "movements occur . . . from the Commander to the leutian Islands" is not documented, and the present study indites that such movement across 185 miles of open sea is nprobable.

he Rat Islands

The Rat Islands (fig. 72) extend 160 miles from Buldir eastward Semisopochnoi. During World War II large military installans existed on Kiska and Amchitka, with small outposts on several her islands. Since about 1948 none of these was occupied, except r brief and intermittent military occupation of Amchitka, par-



GURE 72.—The Rat Islands group, except Buldir Island, where 15 otters were recorded. The aerial survey was conducted on 2 and 3 May 1965 under good to excellent survey conditions. The numbers near the islands indicate the approximate distribution of the 3,147 otters that were observed.

ticularly in 1964 and 1965, and present day Defense Department–Atomic Energy Commission weapons testing activity.

The Rat Islands are noteworthy because it was at Amchitka Island that the first indication of substantial recovery of a sea otter population was noted in 1935. An aerial survey covering all of the Rat Islands was conducted in 1959. Attempts to repeat the survey in 1962 failed because of prolonged harsh weather, but a successful survey was made 2 May 1965. The survey data are recorded in table 21.

Individual islands from which data of particular interest are available are discussed below.

Buldir Island.—This island is 55 miles west of Kiska and is the most isolated of the Rat Islands group. Apparently, for this reason it was the last to be repopulated. No otters were seen during an aerial survey 19 May 1959, but this survey was unsatisfactory because of poor weather conditions (wind and fog). The first modern report of sea otters at Buldir was made by R. D. Jones (1963). He saw an adult male and three females with young there during a visit, 25–28 June 1962. In 1963, between 7 and 19 July, our party recorded five mothers with young and four lone adults on a partial surface survey which included the north coast of the island.

On 2 May 1965 aerial survey conditions were fair (wind 10–15 knots and sun glare) and 15 otters were seen. Numerous sea lions were also present, making observations somewhat difficult. It seems probable to us that the total sea otter population does not exceed 30 animals.

Murie (1940 and 1959), and Williams (1937) did not find sea

TABLE 21.—*Rat Islands group, sea otter population density, estimated from aerial survey counts, 19 May 1959 and 2–3 May 1965*

Island	Otters counted		Estimated total		Square miles of habitat[1]	Otters estimated per square mile	
	1959	1965	1959	1965		1959	1965
Buldir[2]	—	15	—	30	13	—	2
Kiska, L. Kiska, Tanadak I. and Pass	1,127	1,229	1,503	1,652	78	19	21
Segula	47	56	63	75	7	9	11
Pyramid, Davidof, Khvostov	33	39	44	52	8	5	7
Little Sitkin	50	135	66	180	15	4	12
Rat	270	326	360	435	30	12	15
Amchitka	1,560	1,144	2,078	1,525	110	19	14
Semisopochnoi	393	203	524	271	32	16	8
Total	3,480	3,147	4,638	4,220	293	12	11

[1] Square nautical miles of water 30 fathoms or less in depth.

[2] At Buldir Island in July of 1963, 9 otters were counted from the surface along 4 miles of the 10-mile shoreline. The estimated total in that year was 25 otters.

ters at Buldir. The present breeding population probably became tablished there in recent years. This fact is important because e sea otters must have crossed 55 miles of open water to reach ıldir from Kiska. Buldir reef, a 20-mile strip of relatively shallow ater, extends 20 miles west of Kiska to 15 miles east of Buldir. offers depths of less than 30 fathoms where food might be found route, and otters were seen in this area on 27 May 1959 (A. C. artt, letter, 1960).

The observed absence of sea otters at Buldir after intensive ploitation ended in 1911, and their reappearance there in 1962, rnishes another example that, given time, sea otters will find eir way from one island group to another across broad expanses deep open water.

Rat Island.—The available observations of numbers of sea otters Rat Island are listed in table 22. These data indicate that popuion changes at Rat Island followed a pattern similar to the anges observed at Amchitka during the same period and in ore recent years in the Andreanof Islands. No observations are ailable from Rat Island to indicate that population reduction ere was caused by mortality. Presumably, though, as was obrved at Amchitka, mortality at Rat Island caused population duction from a high of 31 otters per square mile of habitat to to 15 per square mile in recent years.

Amchitka Island.—A number of surface and aerial counts and timates of the Amchitka sea otter population have been made ıce 1935. Estimates of the total population, because of the variety methods used in obtaining the basic field data, are approximains and are given to represent an order of magnitude. That these proximations are within reasonable limits is indicated by the ct that they reveal a history of population growth, decline, and ıbilization (with annual fluctuations) that is typical of animals ıen a "seed population" is given complete protection in ideal cant habitat.

The first observation of significant recovery of a sea otter popu-

BLE 22.—*Rat Island sea otter population density in 30 square miles of feeding habitat*

ear	Count	Estimate of total	Otters per square mile	Authority and survey method [1]
3	705	[2] 940	31	F. Beals and G. T. Joynt, aerial count-estimate.
[illegible]	234	312	10	R. D. Jones, aerial survey.
[illegible]	270	360	12	Spencer-Kenyon, aerial survey.
[illegible]	326	435	15	Spencer-Kenyon, aerial survey.

All unpublished reports in U.S. Fish and Wildlife Service files.

Estimate based on the assumption that 75 percent of the otters were recorded.

lation was reported at Amchitka Island by Lt. H. B. Hutchinson, U.S.N., Commander, Aleutian Islands Survey Expedition, in a memorandum of 21 June 1935. The investigation by Naval personnel at Amchitka was in response to a request by the U.S. Department of the Interior. Hutchinson (1935) stated "there are more than one thousand (1,000) adult animals and half that number of pups on the waters surrounding the island." Possible poaching of sea otters by the Japanese was suspected when a vessel believed to be the *Hakyuo Maru* was observed attempting to enter Constantine Harbor, Amchitka Island, on 24 June 1935 (Hutchinson, 1935).

Also, unidentified men were seen on the island in August 1936 (Swicegood, 1936). Accordingly, buildings were erected on Amchitka by the U.S. Bureau of Fisheries in July 1937 (U.S. Bureau of Fisheries, 1938). Sea otter wardens were stationed there intermittently during parts of each year from 1937 through 1940.

During World War II, specific observations of sea otters were recorded by G. T. Joynt (1957) and Beals (1943). Beginning in 1949, many observations were obtained from Amchitka. Selected population counts and estimates that were made are shown in table 23. Other estimates not based on field counts are omitted.

The tendency of a sea otter population to expand to new areas primarily at the periphery of a dense population is illustrated by observations from Amchitka.

Lt. Cdr. S. P. Swicegood (1936), commanding officer of the *Chelan,* conducted field counts of otters at Amchitka on 14–16 August 1936. Although 804 otters were counted along 24 miles of the Pacific coast of the island, only 10 were seen on the Bering Sea coast. A similar condition was observed in the summer of 1937 when C. L. Loy and O. A. Friden (1937) counted 1,241 otters along the Pacific coast of Amchitka and only 80 along the Bering Sea coast. The aerial count by Beals (1943) when he recorded 2,198 otters along the Pacific coast and 1,219 along the Bering Sea coast indicates that between 1937 and 1943 a movement of otters from the Pacific to the Bering Sea coast of the island occurred, probably because the large Pacific coast population caused food depletion along that side of the island.

A review of the field counts at Amchitka between 1936 and 1965, summarized in table 23, demonstrate that a dense population existed on the south side of the island in 1936 (42 otters per square mile) while a sparse one (3 otters per square mile) occupied the north side. Emigration was not rapid but it was appreciable by the year 1939 (south side 40 otters per square mile, north side 1

TABLE 23.—*Amchitka Island sea otter population density in 110 square miles of feeding habitat*

[Only the counts that included all or substantial areas of Amchitka are included. Area measurements from USCGS charts show 72 square miles of feeding habitat on the Pacific (south side) and 38 square miles on the Bering Sea (north side) of Amchitka. Habitat is considered to be water 30 fathoms or less in depth]

Year	Counts			Estimates			Otters per square mile			Authority and survey method
	North side	South side	Total	North side	South side	Total	North side	South side	Total	
1936	10	804	814	[1] 100	3,000	3,100	3	42	28	Swicegood (1936) [2]
1937	80	1,241	1,321	[3] 200	3,102	3,302	5	43	30	Loy and Friden (1937) [2]
1939	217	1,138	1,355	[3] 542	2,845	3,387	14	42	31	Loy (1940) [2]
1943	1,219	2,198	3,417	[4] 1,625	2,931	4,556	43	41	41	Beals (1943) [5]
1949	528	559	1,087	704	745	1,449	19	10	13	Jones (1949) [5]
1959	537	1,023	1,560	716	1,364	2,080	19	19	19	Kenyon and Spencer (1959) [5]
1965	720	424	1,144	960	560	1,520	25	8	14	Kenyon and Spencer (1965) [5]

[1] Estimates made by Swicegood on the basis of counts made along 24 miles of coast and other observations at Amchitka.

[2] Surface surveys.

[3] The estimate given by Loy and Friden in 1937 was 1,760, and by Loy in 1939 was 1,700. Both estimates are given above on the assumption that about 60 percent of the otters are not seen on a surface survey (Lensink, 1958).

[4] Beals did not give a calculated estimate of the totals. This estimate, like other aerial surveys is based on the assumption that about 75 percent of the otters present were recorded.

[5] Aerial survey.

otters per square mile). By 1943 the population density was high on both north and south sides of the island but nearly equal (43 and 41 otters, respectively, per square mile). The difference observed in 1949 (10 otters per square mile of habitat on the south side of the island and 19 on the north side) probably resulted from mortality and emigration caused by depletion of food species that must have occurred in earlier years when the population on the south exposure was very dense (42 otters per square mile). By 1959 the population reached a condition of relative equilibrium with the population evenly distributed (19 otters per square mile) on both north and south shores of the island (fig. 73). By 1965 considerable divergence again occurred, the density on the north side increasing to 25 otters per square mile and on the south side decreasing to 8. Additional detailed studies over a period of years will be necessary to understand the observed population fluctuations. It is possible that significant numbers of otters might move across Oglala Pass to Rat Island.

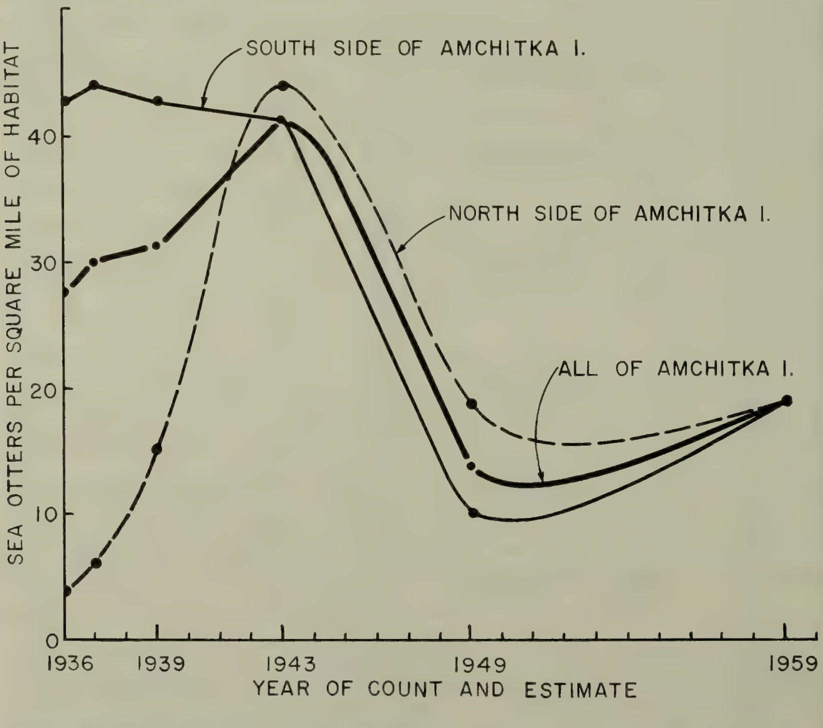
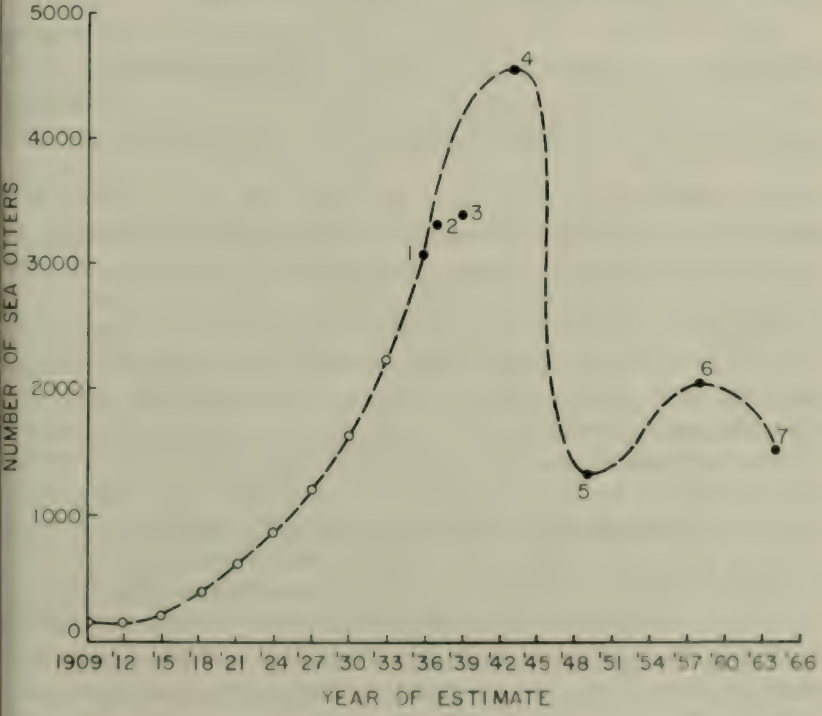


FIGURE 73.—Changes in population density on the north and south coasts of Amchitka Island, 1936–59. Estimates of the population density are based on field counts (see table 23).

Available information indicates that in the 1909–11 period the mchitka sea otter population may have numbered about 100 nimals (fig. 74), and that this population reached maximum size f about 4,500 otters in the early 1940's and then "crashed" to bout 1,500 animals by 1949. A gradual increase to about 2,000 tters apparently occurred between 1949 and 1959, but mortality the winter-spring period of environmental stress caused the opulation to stabilize or possibly to decrease in the early 1960's.

A curve based on field counts and population estimates is shown figures 73 and 74. An estimated rate of increase of 10 percent



IGURE 74.—Estimated curve of the Amchitka sea otter population, 1909–65. No data are available before 1936. The curve from 1909 to 1936 is a projection back from the estimated 1936 population, assuming that the population increased in this period at an exponential rate of 10 percent per year (see section on Seguam Island). Point 1: Population estimate by Swicegood (1936) based on extensive surface counts and observations. Points 2 and 3: Population estimates based on the surface counts of Loy and Friden (1937) and Loy (1940). Point 4: Estimate based on aerial count by Beals (1943). Point 5: Estimate based on aerial count by Jones (1949). Points 6 and 7: Estimate based on aerial counts by Kenyon and Spencer (1960) and Kenyon (1965).

per year in early stages of growth (fig. 74) is based on the observed growth rate in a part of the Andreanof Islands (Seguam Island) where conditions seemed similar to the Amchitka area. The field counts of otters by Loy and Friden (1937) and Loy (1940) are projected to estimated totals on the basis of Lensink's (1958) data indicating that about 60 percent of the otters present may not be seen on a surface survey. These estimated totals assume logical positions (Points 2 and 3) on the curve between the estimated totals of Swicegood (1936), Point 1, and Beals (1943), Point 4. The observations of mortality which occurred after the Amchitka population reached a density of at least 42 otters per square mile are discussed under Limiting Factors.

Lensink (1960) estimated the total population of sea otters at Amchitka on the basis of a field count of otters obtained during a period of weeks in the summer of 1956. His count was 2,568 otters on the eastern half of the island and his total estimate was 6,000 to 8,000 animals.

Our 1959 and 1965 aerial surveys for all of Amchitka were made under excellent observation conditions and our total counts were 1,560 and 1,144 otters, respectively. Why were our total counts much less than Lensink's partial count? Two reasons are suggested: (1) The number of otters at Amchitka may have been reduced between 1956 and 1959. General field observations and observed high winter-spring mortality indicated that population reduction may have occurred. Emigration may also have occurred. (2) Lensink made many trips to different contiguous counting areas during a period of weeks. It is possible that otters moved in the time between counts and the same animals were included in more than one count. If Lensink's (1960) estimate of 6,000 to 8,000 otters at Amchitka is accepted, it would mean that the population there was 55 to 73 animals per square mile of feeding habitat. All other observations and studies made at Amchitka and in other areas indicate that this estimate is very high—nearly twice as large as the indicated maximum population observed by Beals (1943).

In summary, our studies conducted since 1955 and intermittent surveys made since 1935 have indicated that the sea otter population on Amchitka Island grew to a large size, causing overutilization of food resources during the mid-1940's. Population reduction through starvation was then observed and a fluctuating population in balance with the habitat resulted.

It was not surprising, therefore, that our 1965 observation of 1,144 otters at Amchitka was less than our 1959 tally of 1,560, a reduction of 416 animals, or 27 percent. It is interesting to note that during the interval between surveys 637 otters were killed, either by the Alaska Department of Game for their pelts (502 n number) or by the Fish and Wildlife Service for research. Apparently reproduction during the 1959–65 period compensated only partially for the natural and artificial mortality that occurred. It may be concluded that either the habitat limited the otter population below the 1959 level, or the slow rate of reproduction prevented compensatory population growth.

A summary of the probable history of the rise and fall of the Amchitka sea otter population, as deduced from field studies at Amchitka and by analogy with observed rates of growth in other populations, is given below:

1. The 1911 population of otters, at Amchitka, was about 100 animals.
2. At a rate of growth of about 10 percent per year, this population increased to about 3,000 animals in 1935.
3. In the 1935–43 period, the south side of the island was overpopulated and otters moved to the north side. The rate of increase decreased because of mortality caused by overuse of food resources.
4. By 1943 both the north and south shores were crowded by a total population of over 4,000 otters (more than 40 otters per square mile of habitat) and mortality increased.
5. By 1949 field observations indicated that the population had crashed to less than one-third of its 1940–43 maximum. Mortality rather than emigration apparently accounted for much of the decline.
6. Since about 1949 high mortality annually among juveniles and old adults in the late-winter, early-spring season of stress has caused the population to fluctuate within the range of about 1,500 and 2,500 animals (exclusive of dependent young).

Semisopochnoi.—Available information indicates that the sea otter was exterminated at Semisopochnoi during the pre-1911 period of unregulated exploitation. They were vulnerable to hunters because the island is relatively small, the band of feeding habitat along the shore is narrow, and there are no offshore reefs.

No mention is made that sea otters were seen there during the 1936–38 expeditions by Murie (1959) and his assistants. V. B. Scheffer told me in 1964 that sea otters were not seen when he landed on Semisopochnoi on 4 July 1937.

Beals (1943), speaking of military pilots who developed much interest in the distribution and abundance of sea otters while stationed on Amchitka, says "These same pilots have made many scouting flights around Semisopochnoi Island and report that they have never seen sea otters in that vicinity."

On the aerial survey of 19 May 1959, when observation conditions were excellent, we saw 393 otters (16 per square mile of habitat) at Semisopochnoi Island. It thus appears that the animals moved from Amchitka across nearly 30 miles of open water to this island after 1943, when the Amchitka population approached maximum size and population pressure stimulated emigration. By 1965, the population at Semisopochnoi had decreased to an estimated 8 otters per square mile of habitat (table 21).

Delarof Islands

This small group (fig. 75) is technically part of the Andreanof group (U.S. Board on Geographic Names, 1963), but is treated as a separate unit here. The group includes a distance of about 33 miles from east to west and is separated from Tanaga Island

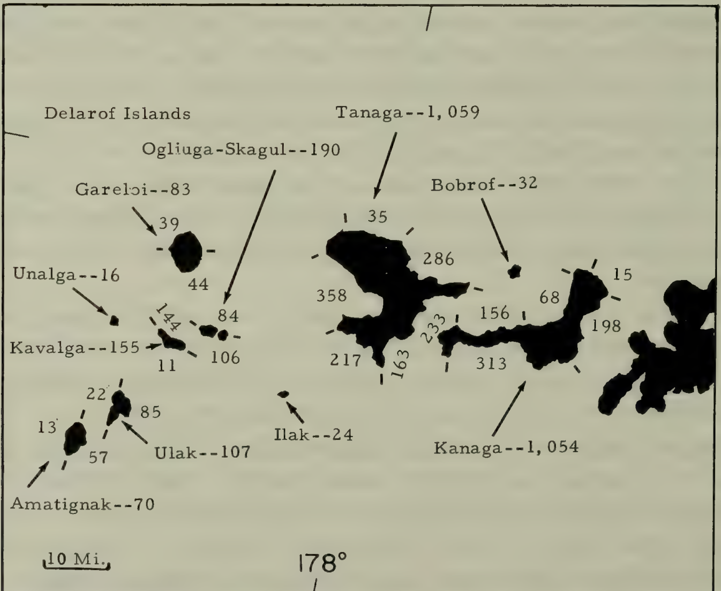


FIGURE 75.—The Delarof Islands of the western Andreanof Islands were apparently among the few Aleutian areas where the sea otter remained in 1911 when it was given protection. A large population developed here and at Kanaga and Tanaga Islands by the late 1940's, but population pressure did not cause repopulation of nearby Adak until the mid-1950's. The number of otters observed on aerial surveys of 2 and 3 May 1965, as shown on this map, was 2,790.

the east by 14-mile-wide Tanaga Pass and from the Rat Islands the west by 50-mile-wide Amchitka Pass. The Delarofs have human inhabitants.

Murie (1940) found a thriving sea otter population at Ogliuga 1936. Joynt (1957) says of his 1943 aerial observations that—

> e most densely grouped of any pod of sea otter observed was on one end the sand bars exposed at half tide that lies between Kavalga Island and gliuga Island in the Delarof Islands group.

Data from the 1930's, as cited above, indicate that the Delarof id Rat Islands populations approached maximum size at about e same time. Because of the width of Amchitka Pass (50 miles), appears probable, as pointed out by Lensink (1960), that rem- nt populations remained in 1911 in both the Rat and Delarof land groups. The habitat at Amchitka and in the Ogliuga- avalga Islands areas, is similar in having extensive shallows tted by submerged or partially submerged reefs. Although these fered feeding habitat and a place of refuge to the sea otter, they esented considerable hazard to early sea otter hunters and were obably instrumental in preserving the species.

On 26 May 1959, our aerial observations (table 24) revealed at the number of otters per square mile of habitat in the Delarofs as the highest of any island group that we surveyed. This condi- on is of particular interest because the Delarofs were among the st Aleutian islands to be repopulated. By May 1965, our observa- ons indicated that the Delarof population had dropped by ap- oximately 50 percent (table 24).

It may be postulated that after the population peak, which obably occurred in the 1930–40 period, emigration to Tanaga

BLE 24.—*Delarof Islands sea otter population density estimated from aerial survey counts of 26 May 1959 and 2–3 May 1965*

	Otters counted		Estimated total				Square miles of habitat [1]	Otters estimated per square mile	
sland	1959	1965	1959		1965			1959	1965
relof	41	83	68		111		9	8	12
alga	51	16	85		27		8	10	3
valga	275	155	367	[2] 1,152	207	529	52	22	10
liuga	112	144	149		192				
igul-Tag-Ugidak	281	46	375		77				
mp Rock	134	32	179		53				
k	49		82						
k	352	107	469	[2] 605	148	260	20	30	13
atignak	102	70	136		117				
Total	1,397	653	1,910		927		89	Av. 21	10

Includes water of 30 fathoms or less in depth as measured from U.S. Coast and Geodetic rvey charts.

Closely associated islets and islands.

took place. After the Tanaga population exceeded the carrying capacity of the available habitat, otters moved westward to the Delarofs again as well as eastward to Kanaga and Adak. Thus, we observed a second population peak in the Delarofs in 1959. This resulted in food depletion and a subsequent "population crash" bringing the population density from 21 down to about 10 otters per square mile by May 1965 (table 24). Whether oil from the San Patrick, which was wrecked on the south shore of Ulak Island during the winter of 1964–65, was a factor in population reduction is not known.

Andreanof Islands

The Andreanof Islands (figs. 76 and 77) (excluding the Delarof group) extend for a latitudinal distance of about 230 miles from Tanaga on the west to Seguam on the east. Human populations in this group are at the U.S. Naval Station on Adak, and Atka

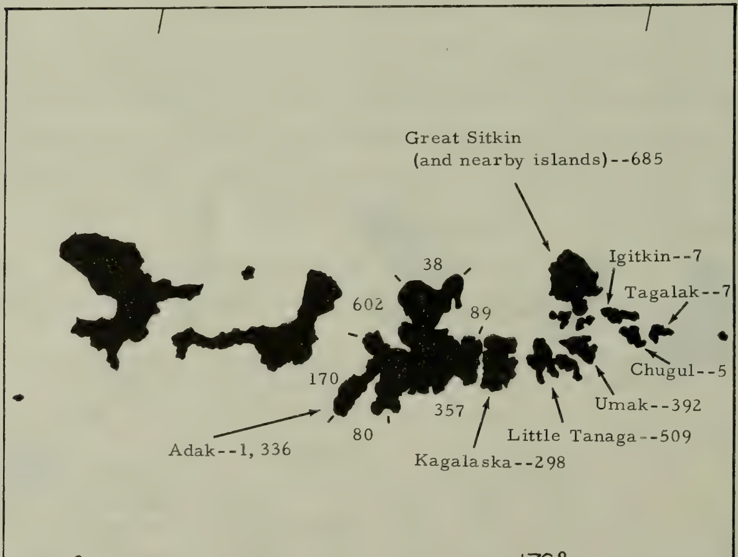
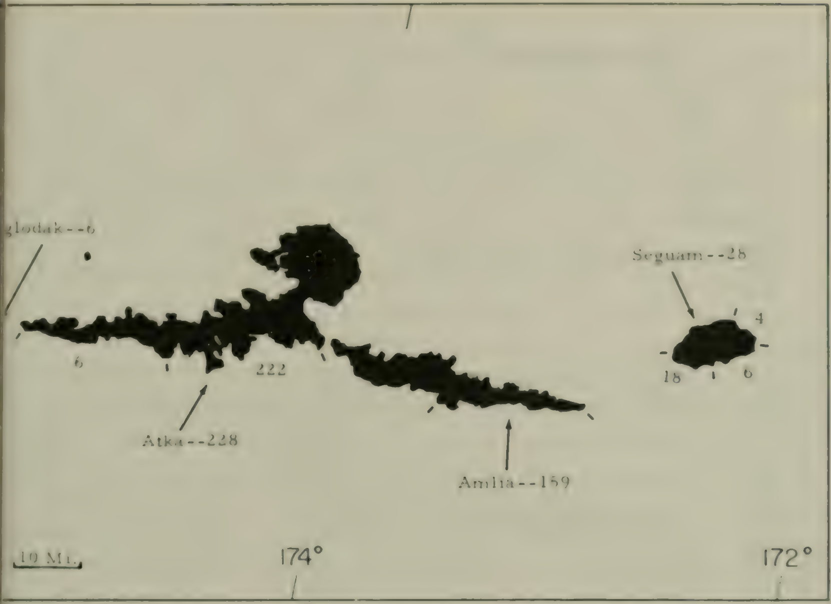


FIGURE 76.—The Adak–Great Sitkin Island areas in the central Andreanofs were repopulated during the 1950's and early 1960's by otters from the Delarof and Kanaga and Tanaga Islands. No otters were found on a survey of Adak in 1952, but on an aerial survey in 1954 a count of 48 was obtained, and by 1965 the count increased to 1,336. On aerial surveys of 25 and 26 April 1965, 3,239 otters were observed in the area shown.



URE 77.—The colonies on the southern exposures of Atka and Amlia Islands, in the eastern Andreanof Islands, appear to be augmented from he large population in the central Andreanofs (Adak–Great Sitkin area). Repopulation is proceeding at Atka and Amlia as it did at Amchitka, where a large population developed on the south side of the island before he north exposure was repopulated. On aerial surveys of 21 April and 6 May 1965, 421 otters were observed in the area shown.

llage on Atka Island. Several other islands were occupied by the litary during World War II.

The group is of special interest because detailed observations population growth and range extension of sea otters were obined there. Aerial surveys of the entire group were conducted late May 1959, early April 1962, and early May 1965. In all gnificant areas these surveys were conducted with excellent servation conditions and by the same observers (D. L. Spencer d Kenyon). The surveys offer the best comparable data availle. Field observations, population estimates, and population nsity are summarized in table 25.

Analyses of observed population growth and of population flucations are presented for individual islands on the following pages d a discussion of the group as a unit is presented below.

The sea otter populations at islands from Tanaga on the west Seguam on the east (exclusive of Bobrof Island, which is small

TABLE 25.—*Andreanof Islands counts and estimates of sea otters obtained on three aerial surveys to show movements of otters*

[Surveys were made on 25–27 May 1959, 5–6 April 1962, and 19 April to 8 May 1965. The islands are listed in geographical sequence, top to bottom from west to east. Counts made at small islets closely associated with large ones are combined with the count for the large island].

Island	Otters counted			Otters estimated			Square miles of habitat	Otters per square mile of habitat		
	1959	1962	1965	1959	1962	1965		1959	1962	1965
Tanaga	902	898	1,059	1,203	1,197	1,412	83	14	14	17
Bobrof [1]	57	—	32	76	—	53	2	38	—	26
Kanaga	1,822	846	1,054	2,429	1,128	1,405	95	26	12	15
Adak	1,718	2,260	1,336	2,291	3,013	1,781	75	31	40	24
Kagalaska	1	251	298	1	335	397	15	<1	22	26
Little Tanaga	0	214	509	0	285	679	22	0	13	31
Umak	0	94	392	0	157	523	9	0	17	58
Anagaksik	0	14	0	0	28	0	1	0	28	0
Great Sitkin [2]	0	325	710	0	433	947	80	0	5	12
Atka	33	50	228	44	83	304	200	<1	<1	1.5
Kasatochi	0	0	[3] NS	0	0	—	5	0	0	—
Koniuji	0	0	NS	0	0	—	1	0	0	—
Amlia	83	91	159	111	152	212	150	<1	1	1.4
Seguam	14	23	28	28	38	47	28	1	1	2
Total	4,630	5,066	5,805	[4] 6,183	6,849	[4] 7,760	766			

[1] Bobrof is a small island and was not surveyed in 1962. It is omitted from certain calculations based on this table.

[2] In addition to Great Sitkin the counts made at 12 small islands from north of Umak to Atka are included.

[3] NS = no survey was conducted.

[4] When Bobrof Island is excluded the total becomes 6,107 in 1959 and 7,707 in 1965.

nd was not surveyed in 1962) increased from 6,107 otters in 1959 6,849 in 1962 (table 25), a gain of 742 otters or 12.1 percent in years. In the next 3-year period (1962–65) the same area gained 58 otters (7,707 minus 6,849, table 25) or 12.5 percent.

Within the Andreanofs, emigration occurred when islands be- ıme densely populated. For example, the Kanaga population lost 301 otters (2,429 minus 1,128, table 25) between 1959 and 1962, hile nearby islands (Adak, Kagalaska, Little Tanaga, Umak, nagaksik, Great Sitkin, and adjacent islets) increased from 292 to 4,269 (table 25), a gain of 1,977 otters or 86 percent. ecause immigrating otters may have moved into the available acant habitat surrounding the above named islands from Tanaga well as Kanaga, it is not possible to separate the increase repre- nting reproduction from that caused by immigration in these eas. The conclusion is indicated that in the Andreanofs the total a otter population may grow at a rate of about 4 to 5 percent r year and that in the 1975 to 1980 period the population there ay number over 12,000 otters or about 14 animals per square ile of habitat.

Tanaga Island.—The repopulation of Tanaga Island appears to ive been well underway by the mid-1930's. Williams (1937) entions it along with Amchitka and Ogliuga as being one of the nost productive" islands. D. Hooper (*in* Jones, 1953) indicated at the otter population there was large in 1953. Until our aerial rveys, no comprehensive quantitative assessment of the otter pulation at Tanaga was made. Available population data are mmarized in table 26.

The few observations available indicate that population overflow om the Delarof Islands repopulated Tanaga during the 1930's, d that during the late 1940's or early 1950's the local population ached maximum size. During the mid- or late-1950's, the popula- on density probably became reduced through emigration to anaga Island and remained stabilized from 1959 to 1962 at about otters per square mile of habitat. The increase to about 17

BLE 26.—*Tanaga Island sea otter population density in 83 square miles of feeding habitat*

Year	Count	Estimate of total	Otters per square mile	Authority and survey method
7	(?)	150+	2	O. J. Murie and V. B. Scheffer, surface survey.
3	1,000 (ca.)	1,000+	12+	D. Hooper, surface survey (in Lensink, 1960)
9	902	1,203	14	Spencer and Kenyon, aerial survey.
2	898	1,197	14	Spencer and Kenyon, aerial survey.
5	1,059	1,412	17	Spencer and Kenyon, aerial survey.

otters per square mile in 1965 may have resulted from emigration from densely populated Kanaga.

Kanaga Island.—The Murie expedition visited Kanaga in 1936 and Williams (1937) states that no sea otters were seen. Natives reported to him, however, that otters did "occur occasionally or sparingly" there. By 1943, Kanaga was apparently only sparsely repopulated. Joynt (1957) says that in 1943:

> A few stray animals were observed along the south shore of Kanaga but I do not recall ever observing more than 6 or 8 animals on the three or four flights over this area.

By 1953 the population had increased greatly. In June of that year D. Hooper (*in* Jones, 1953) spent 21 days on Kanaga. He walked 40 miles of beach and counted 575 otters. After examining a number of inshore areas at Tanaga he estimated that the otter populations of Kanaga and Tanaga Islands were large, "probably numbering several thousand" animals.

Data obtained on the 1959 and 1962 aerial surveys indicate that the Kanaga population was near maximum size in 1959. The precipitous population drop from an observed total of 1,822 otters in 1959 to 846 in 1962 indicates that the estimated 1959 population of 26 otters per square mile of available feeding habitat may have depleted food resources and precipitated substantial emigration (and mortality?) during the elapsed 3-year period. By 1965 a slight increase, probably resulting from crowding at nearby Adak, had occurred (table 27).

On a dory survey in 1957 along a 19-mile sample of coast, Lensink (1960) recorded 566 otters. Along the same coastal sample on our 1959 aerial survey we recorded 549 otters and in 1962 the aerial count there was 404. The similarity of the 1957 surface

TABLE 27.—*Kanaga Island sea otter population density in 95 square miles of feeding habitat*

Year	Count	Estimate of total	Otters per square mile	Authority and survey method
1943	6–8	few	(?)	G. T. Joynt (1957) flew repeatedly over area.
1953	575	many	(?)	D. Hooper (*in* Jones, 1953) walked 40 miles of beach and counted otters.
1957	566	[1]3,000–5,000	32–53	C. J. Lensink (1960), dory survey along 19 miles of coast.
1959	1,822	2,429	26	Spencer and Kenyon, aerial survey, entire island.
1962	846	1,128	12	Spencer and Kenyon, aerial survey, entire island.
1965	1,054	1,405	15	Spencer and Kenyon, aerial survey, entire island.

[1] Because this estimate was made from data gathered along the south shore, where more habitat is available than along the north shore, the estimated upper limit may be somewhat high.

nd 1959 aerial observations indicate that the total populations these two years were at least similar, or perhaps larger in 1957, nce aerial counts usually include a higher percentage of animals resent. The number of otters seen along different parts of the ast on aerial surveys when correlated with the distribution of vailable feeding habitat around the island, indicate that the stribution of otters along the shores of the entire island varies cording to the amount of habitat available.

The coastal zone of sea otter habitat is narrow along much of e north shore of Kanaga. In 1959, along 30 miles of the north ore, we observed 415 otters (14 otters per mile of coast), while ong 45 miles of the mostly southern and eastern coast, where the bitat zone is wider, we recorded 1,407 otters (31 per mile of ast).

These data suggest that Lensink's (1960) "somewhat conserva-ve" estimate of 3,000 to 5,000 otters at Kanaga (32 to 53 otters r square mile of feeding habitat) based on his sample count ong the south shore may have been quite realistic (table 27).

Adak Island.—The U.S. Naval Station, Adak, was established in e early 1940's. It remains today the most important center of uman population in the Aleutian Islands and furnished facilities r sea otter studies in the outer Aleutian area.

The Murie expeditions did not find sea otters at Adak and ob-ined no information from natives that they were observed there recent years (Williams, 1937).

Although 14 otters were seen in 7-mile-wide Adak Strait between anaga and Adak in 1943 (Lensink, 1960), few if any crossed the rait and became established at Adak during the 1940's.

When I visited Adak on 31 October to 5 November 1947, I saw sea otters and could find no report of an observation there. either did R. D. Jones see any otters (table 28) on a complete rcuit of Adak by dory in 1952. The first indication that sea otters d become established at Adak was an observation of 48 animals uring an aerial survey in 1954 by Lensink (1960).

The influx of otters that began from Kanaga to Adak in the early 50's proceeded rapidly and was documented during the 1959 and 62 aerial surveys. It appears that emigration from Kanaga (26 ters per square mile in 1959) to Adak (31 otters per square mile 1959) continued during this period and that a large population Kanaga during a period of years had depleted food resources ere. Adak, on the other hand, was repopulated only recently n 1959) and serious food depletion did not occur until the

TABLE 28.—*Adak Island sea otter population density in 75 square miles of feeding habitat*

Year	Count	Estimate of total	Otters per square mile	Authority and survey method
1947	0	0	0	Kenyon field notes. No otters seen or reported seen.
1951	0	0	0	R. D. Jones, surface survey, west side only.
1952	0	0	0	R. D. Jones, surface survey entire island.
1954	48	80	1	C. J. Lensink (1960), air survey. All otters seen on west side of island.
1954	1	—	—	R. D. Jones. First recorded sighting at Adak Naval Station, on east side of island.
1957	399	997	13	C. J. Lensink (1960) and R. D. Jones, surface survey. Most otters on west side of island.
1959	1,718	2,291	31	Spencer and Kenyon, aerial survey.
1962	2,260	3,013	40	Spencer and Kenyon, aerial survey.
1965	1,336	1,781	24	Spencer and Kenyon, aerial survey.

1962–65 period. All available observations are listed in tables 27 and 28.

Kagalaska Island.—Kagalaska is uninhabited by man. Most of the island is precipitous. Although its coastline is about 35 miles long, the band of shallow water surrounding it and offering sea otter feeding habitats is relatively narrow. As at nearby Adak, sea otters were apparently exterminated at Kagalaska before 1911.

On the 1959 aerial survey we recorded one otter there. Between then and the 1962 survey the influx from nearby Adak was rapid and had apparently passed its peak in 1965 (table 29 and fig. 78).

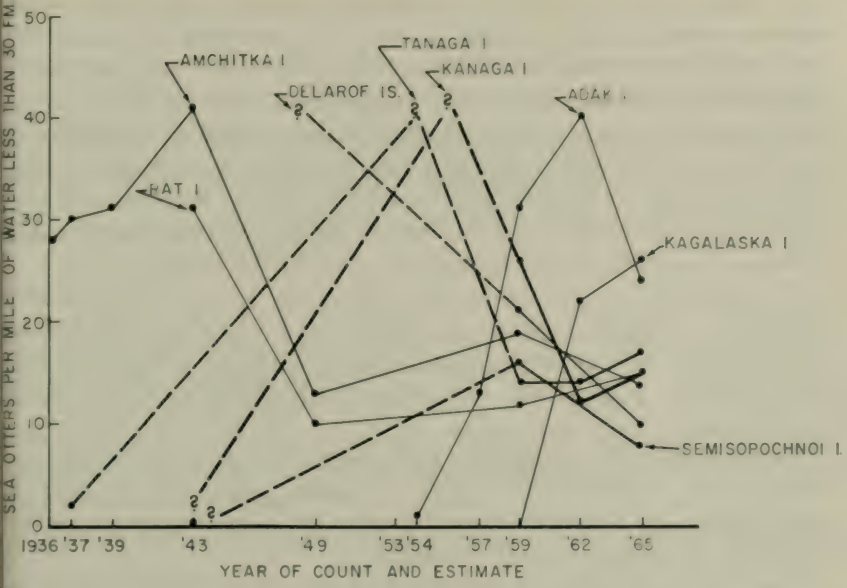
Atka Island.—The village of Atka is the farthest west location of a small Aleut population today. The village is on Nazan Bay near the eastern end of the 55-mile long island.

Both R. D. Jones and I were told repeatedly by Aleuts living at Atka that during the 1940's sea otters were occasionally seen at Vasilief Bay near the east end of Atka. The 1959, 1962, and 1965 aerial surveys confirmed that a small and growing sea otter colony is resident in this area (table 25).

Vasilief Bay offers ideal sea otter habitat. The main body of the bay is dotted with rocks and islets. Numerous channels among them and irregular shores offer many areas that are sheltered

TABLE 29.—*Kagalaska Island sea otter population density in 15 square miles of feeding habitat*

Year	Count	Estimate of total	Otters per square mile	Authority and survey method
1954	0	0	0	Lensink, aerial survey.
1959	1	2+	<1	Spencer and Kenyon, aerial survey.
1962	251	335	22	Spencer and Kenyon, aerial survey.
1965	298	397	26	Spencer and Kenyon, aerial survey.



IGURE 78.—Populations of sea otters at several Aleutian Islands have increased to maximum size and then crashed between 1936 and 1965. Estimates of otters per square mile of habitat (waters within the 30-fathom curve), which are based on extensive field counts, are shown as dots which are connected by solid lines. Observations of "few," or "many," or "thousands" are shown by question marks and connected by broken lines. (For data, see tables 21–29.) Population peaks apparently occurred between aerial surveys at Adak and Kagalaska Islands.

rom wind and rough water in storms. This habitat apparently ttracted the occasional otter that wandered eastward from the rge population in the western Andreanofs, causing the colony form and to be augmented by further immigration. In the 1959 1962 period, the colony increased by 86 percent and between 962 and 1965 by 375 percent. Repopulation of the north side of tka had not begun in 1965.

Amlia Island.—It is 40 miles long, has no human inhabitants nd except near the west end is seldom visited by the Aleutian atives of nearby Atka Village. The U.S. Coast and Geodetic Surey has not as yet (1965) issued a chart showing soundings of mlia's inshore waters. The area of sea otter feeding habitat (table 5) was estimated on the basis of measurements taken at Atka ecause the two islands appear similar.

Vague reports that I received from the hunters of Atka during e 1940's and 1950's indicated that a small number of sea otters was resident at Amlia for a number of years. The 1959 aerial surveys revealed that a small population occupied the south side of the island, the greatest number being near the eastern extremity (fig. 77 and table 25). The 1962 survey confirmed that this population is resident but time was not available then to resurvey the north coast. In 1965 the entire coastline was surveyed but otters were seen only on the south coast. The increase between 1962 and 1965 from 111 to 212, a doubling of the population, may in large measure be attributed to immigration from the west.

If repopulation of this island proceeds in a way similar to population spread observed in other areas (Amchitka and Adak, for example) the north coast can be expected to repopulate after the present population on the south coast has increased considerably.

Seguam Island.—This is the easternmost island in the Andreanof group (U.S. Board on Geographic Names, 1963). It is separated from Amlia by Seguam Pass, 16 miles of deep water and strong currents. It has no human inhabitants.

The Murie expeditions did not find sea otters at this island but information from Aleutian natives indicated that otters had been seen there (Williams, 1937). The first specific evidence that sea otters occupied Seguam was found on our 1959 aerial survey. The 1962 and 1965 surveys confirmed that the small population is resident and is growing slowly. An increase of approximately 10 percent per year (from 28 to 47 otters in 6 years) may represent the rate of increase due to reproduction in an isolated, uncrowded population.

Because the population today is so small (table 25), it seems unlikely that otters survived the period of unregulated exploitation in this location. It appears more probable that wanderers from the larger populations in the west reached Seguam in recent years and remained there either because the habitat is desirable or because the width of Amukta Pass discouraged emigration to the Islands of Four Mountains. The relatively slow rate of increase however, indicates that immigration is, as yet, not appreciable at this rather isolated location.

Islands of the Four Mountains

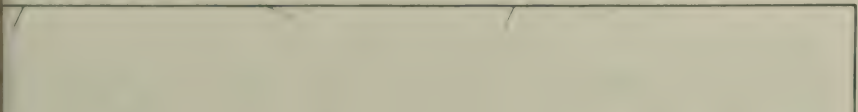
From Amukta Island northeastward to Kagamil Island or Samalga Pass is about 70 miles. There is no human population in this island group, therefore few surface observations are available The survey of 3 March 1960 covered all coastlines and was made under excellent conditions. On 7 April 1962, survey condition were fair and only about 50 percent of the coastline of each of the main islands was surveyed. On neither survey were otters seen. It is probable that no sea otters occupy this group at present.

The available sea otter habitat around the seven steep-sided islands in this group is 88 square miles. When compared with Gareloi, a similar island having a sea otter population of 8 otters per square mile of habitat, the estimated future population in the Islands of Four Mountains may be about 700 otters.

Fox Islands

This group (figs. 79 and 80) includes the islands in the 240-mile sector of the Aleutians between Samalga Pass and Isanotski Pass at the western extremity of the Alaska Peninsula. Amak Island, off the north coast of the Alaska Peninsula, although not one of the Fox Islands, is included in this discussion because of its proximity to Unimak Island.

Among the Fox Islands at present there are two small, widely



FIGURES 79.—The colony at Samalga Island and in the vicinity of Cape Sagak, Umnak Island, at the western extremity of the Fox Islands, is a small but permanent one. Otters were observed there during aerial surveys in 1960 (6), 1962 (10) and, as shown on the map, in 1965. This is the most isolated Aleutian colony. Complete surveys of Umnak and Unalaska Islands were made in March 1960 and April 1962. Only the south exposures were surveyed on 8 May 1965.

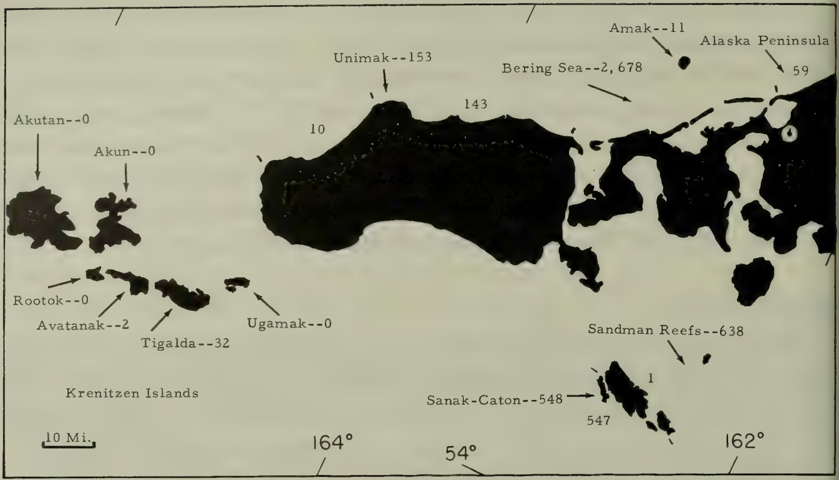


FIGURE 80.—The Sanak–Caton Islands and Sandman Reefs areas were last surveyed on 8 April 1962. All other surveys of the eastern Fox Islands shown on this map were made on 8 May 1965. The total number of otters observed on these two surveys in the areas shown is 4,121.

separated, but apparently permanent, sea otter colonies and one large population, but most of the available habitat is unoccupied. The small Samalga–Cape Sagak colony and the other on the northeast coast of Tigalda are apparently growing slowly. The large Bering Sea population off the north coast of Unimak Island and the western Alaska Peninsula, already of considerable size, is possibly augmented by an influx of otters from the Sanak–Sandman Reefs areas in the North Pacific Ocean. R. D. Jones (letter, 10 April 1964) reports that he—

> observed an adult otter right smack in the narrows of the north end of False Pass [Isanotski Strait]. I've never seen one there before. He was at the time being swiftly carried into Bering Sea by the tide.

The available sea otter habitat in the Fox Islands is at present sparsely populated. Because of the large extent of this area, repopulation will probably require many years.

The western Fox Islands.—Human settlements include Nikolski Village, a sheep ranch, and a DEWline site near the south end of Umnak Island, and a sheep ranch and Reeve Aleutian Airways' installation near Cape Tanak on the north end of 65-mile long Umnak. On Unalaska Island the village of Unalaska is the largest of the extant native Aleutian settlements. There is also a DEWline site at Driftwood Bay on Unalaska Island. Counts of otters from veral sources and estimates of all otters in this area are sum- arized in table 30.

Several Aleutian natives who hunt and fish in the waters off the uth end of Umnak and near the east end of Unalaska have given e verbal reports over a period of several years (1950–62). Fred d Antone Bezezekoff of Nikolski Village, Umnak Island, have ld me of repeatedly seeing a small number of otters in the cinity of Samalga Island and Cape Sagak at the southwest end Umnak Island. Their highest count was 14 otters (F. Bezezekoff, tter 13 March 1961). The three aerial surveys of the Fox Islands dicate that the small colony at the western extremity of Umnak land is permanent but no increase is indicated. Apparently few nderers enter this extensive western Fox Islands area which is olated from other populations.

No one at Unalaska reported a sea otter sighting in the 1950–62 riod. That sea otters are now repopulating Unalaska is indicated a recent report. On 19 and 20 July 1968, C. H. Fiscus, A. M. hnson, and H. Kajimura (personal communication) saw an otter Kismaliuk Bay, on the north coast of the island, and another off derip Point at the island's southwestern extremity.

The available sea otter habitat adjacent to the islands from malga Island to Akutan Pass is about 570 square miles. If this bitat can support about 12 otters per square mile, the estimated ture population of this area may eventually be about 6,800 otters.

Krenitzin Islands.—The Krenitzin Islands occupy a 45-mile ctor of the Fox Islands from Akutan Pass on the west to Unimak ss. The village of Akutan, on Akutan Island, is the only human tlement in the Krenitzins. Occasional otter sightings near kutan are reported by native Aleut fishermen (Lensink, 1958).

BLE 30.—*Numbers of sea otters observed and estimated population in the Fox Islands group*

[The many islands, islets, and rocks where no sea otters were observed are omitted]

Island and year	Otters counted	Estimated total
alga-Umnak:		
1962	10	20
1965	9	20+
and Old Man Rocks: 1957 [1]	1	2
alda:		
1960 [2]	11	22
1965	32	53
mak-Amak:		
1962	811	1,081
1965	2,892	3,856
Total (highest counts)	2,935	3,931

Lensink (1958) aerial survey.

Surface survey of June 1960.

On 23 August 1962, R. Thomas (fur seal research biologist) sighted one otter in Akutan Bay (personal communication).

On 3 and 4 March 1960, D. L. Spencer and I surveyed this island group in detail under good weather conditions. On 7 and 8 April 1962 and again on 8 May 1965, wind permitted us to make only an inadequate survey of a small area off Tigalda Island, the only place where sea otters were previously seen. Only three otters were sighted in 1959 and 1962. In addition to the aerial survey data, I obtained information during surface surveys by dory on 26–29 June 1960 when I counted 11 adult otters and 6 young with mothers at Tigalda Island. During the 1965 survey, in spite of wind and rain, we sighted 32 otters there (table 30).

During May and June of 1960 and 1962, C. H. Fiscus (fur seal research biologist) spent considerable time in the Krenitzins while conducting pelagic sealing investigations in Unimak Pass and Bering Sea. The sealing vessel anchored on numerous occasions in different bays and bights and Fiscus went along the shore by dory in several areas. These included Avatanak Strait, Akun, Seredka, and Trident Bays at Akun Island; Rootok Strait, Durbin Strait, Durbin Bay at Tigalda Island; Ugamak Strait, Ugamak Island; and the south shore of Akutan. Although a careful search was always made for sea otters, Fiscus told me that none was observed. It therefore appears probable that the small colony along the northeast shore of Tigalda Island is the only one in the Krenitzin Islands and that otters reported occasionally from Akun Strait are wanderers.

The area of sea otter habitat adjacent to the Krenitzin Islands is about 200 square miles. If it may support about 12 otters per square mile, the future otter population may be about 2,400.

Unimak and Amak Islands.—Unimak Pass separates Unimak Island from the Krenitzin Islands. The distance from Unimak Pass to Amak Island is about 100 miles. A Coast Guard Station at Cape Sarichef is the only human settlement in the study area.

The greatest number of sea otters in this area inhabit the shallow waters of the Bering Sea off Izembek Bay in the vicinity of Amak Island and off the north central portion of Unimak. Depths of 20 fathoms or less extend to about 8 miles from shore and the 30-fathom curve extends to about 15 miles from shore. The majority of the 811 otters observed on the 8 April 1962 aerial survey were seen near the 20-fathom curve. Observation conditions were good to excellent during this survey and sectors were systematically covered between 1 and 15 miles from the shore of Unimak Island and the tip of the Alaska Peninsula. In addition, I conducted urface investigations in these waters with C. H. Fiscus and his rew of biologists from 7 to 10 July 1960 while on board the M/V *Windward.* Otters were found over waters as deep as 23 athoms. An investigation of about 2 miles of beach on Amak sland in 1960 revealed no remains of sea otters or droppings. Vhile walking the same beach in 1963, Fiscus found the remains f two adult sea otters but saw no living animals on shore. It ppears that this population leads a predominantly offshore existnce. Some observers (Lensink, 1958) speculate that this group f otters migrate seasonally. No evidence to support this supposiion is available.

During aerial surveys of walruses on 27 March 1961, the Amak sland area was visited. Fog, however, prevented a satisfactory urvey. A few otters were seen through gaps in the fog northeast f Amak Island, north of Izembek Bay, indicating that a number vere present. It seems reasonable to conclude that, as in other reas, otters are resident there throughout the year. Where they ear their pups is unknown.

In 1963, R. D. Jones and C. P. McRoy (Jones, letters Dec. 1963 nd March 1964) found five dead sea otters in April, June, August, nd November on the Kudiakof Islands which separate Izembek Bay (55°20′ N. lat., 162°30′ W. long.) from the Bering Sea. They lso saw several living otters in Izembek Bay, 17–19 December 963. These observations and the lack of similar ones in past years ndicated a population increase in the southwestern Bristol Bay rea which was confirmed during the 1965 aerial survey.

One of the significant observations we obtained during the 1965 erial survey was of the very large number of otters occupying hallow water north of the Alaska Peninsula and Unimak Island table 30). Many of these animals were gathered into large rafts vell outside the surf line, apparently sleeping on their backs at nidday when we made our survey (fig. 81). Scattered individuals vere feeding. Although the 1965 survey showed that the majority f the otters in this area were within the 3-mile limit, the 1962 urvey demonstrated that numbers of them may feed in waters ear the 20-fathom curve, which in this area is from 5 to 8 miles rom shore. A possible reason that more otters were near shore luring the 1965 survey was that a north wind of approximately 0 knots had blown steadily for several days before our survey. At the time of the survey, the wind had dropped to 10–15 knots but vas still from the north.

The indicated great increase in the otter population from Fox slands to Port Moller may probably be attributed primarily to

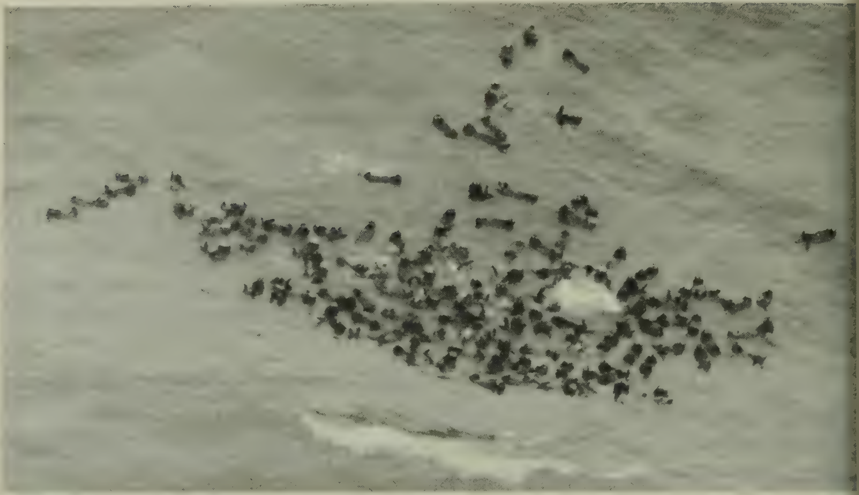


FIGURE 81.—This group of 128 otters slept on the open sea about 2 miles off the north coast of Unimak Island, Alaska. No kelp beds are found in this offshore location. Available evidence indicates that animals in this area rarely come ashore. (KWK 65–17–8)

three factors: (1) An influx of otters from the Sanak Island–Sandman Reefs area. (2) A north wind of several days' duration before and during our 1965 survey may have concentrated large numbers of otters near shore from their extensive offshore feeding grounds. During the 1962 survey of this same area, we found otters more scattered than in 1965. In 1962 they were spread over many square miles of open water. Possibly we failed to see many of them in 1962. (3) A large number of mothers carrying young were observed during both surveys—obviously reproduction accounted for some but certainly not all of the observed population increase in this area.

If the habitat (more than 1,000 square miles) may be populated as densely as some of those of the Aleutian Islands, the population might reach from 10,000 to 15,000 otters. No quantitative study of the marine invertebrate fauna of southwestern Bristol Bay has been made. A qualitative study by McLaughlin (1963), however, revealed a variety of crustaceans and molluscs in this area and suggests that it is rich. The large numbers and variety of aquatic birds and marine mammals there indicate that food species are abundant.

We extended the 1965 survey along the north shore of the Alaska Peninsula about 10 miles northeast of Port Moller but found no sea otters beyond the mouth of that bay. Our observations ggest that Port Moller (56° N. lat., 160°50′ W. long.) is near the ortheast extremity of the sea otter's range in Bristol Bay. A sea tter taken "... near the Naknek River ..." at about 58°40′ N. lat., northeastern Bristol Bay "... where they are rarely to be found" U.S. Bureau of Fisheries, 1911, p. 56) was probably a wanderer om southwestern Bristol Bay.

anak Island and Sandman Reefs

Sanak Island (fig. 80), which supports a small village, is aproximately 20 miles southeast of the eastern extremity of Unimak land. Between Sanak Island and the Alaska Peninsula the Sandan Reefs consist of extensive shallows having a number of posed rocks and islets.

Sea otters were reported in the Sanak Island-Sandman Reefs rea as early as 1922 (McCracken, 1957), but must have been ery scarce at that time (Lensink, 1962). The Murie expedition ceived reports of otters in this area in 1936 but found none Williams, 1937). Aerial surveys in 1957 and 1962 indicate that substantial population now in this area is increasing (fig. 80 nd table 31).

Aerial surveys in 1957 by Lensink (1958) and my observations otained on dory surveys of 20–23 June 1960 indicated that few a otters occupied waters surrounding Caton Island and that the nimals were more numerous among the reefs off the southeast ast of Sanak. Aerial surveys of 10 April 1962, during excellent eather conditions, confirmed these observations. The majority the otters observed on both aerial surveys were concentrated mong reefs and islets off the southwest coast of Sanak Island

ABLE 31.—*Numbers of sea otters observed and estimated population in the Sanak Islands and Sandman Reefs areas*

Area	Aerial surveys		Estimated total in 1962
	1957 [1]	1962 [2]	
nak area:			
Sanak Island and associated reefs	236	525	700
Caton Island and associated reefs	15	23	46
Total	251	548	746
ndman Reefs:			
Cherni Island	271	259	345
Clubbing Rocks	33	2	4
Little Goose Island	76	82	137
Deer Island and all reefs not named above	123	295	393
Total	503	638	879
Total both areas	754	1,186	1,625

[1] Aerial survey by Lensink (1958) on 19 July 1957.
[2] Aerial survey by D. L. Spencer and Kenyon on 10 April 1962.

within the 20 fathom curve. Lensink (1958) saw no otters in the relatively deep waters off the northeast shore of Sanak and only one was seen there during the 1962 survey.

Flights over the Sandman Reefs on 10 April 1962 were undertaken when conditions were excellent. We viewed the exposed rocks and islets and examined most of the open water. Otters could be seen on the glassy surface within a track about 2½ miles wide.

Because of the irregular bottom topography of this area, it is difficult to measure from charts the amount of available sea otter habitat. The approximate measurements obtained, however, indicate that the Sanak Island-Sandman Reefs area may furnish nearly 900 square miles of feeding habitat. With about two otters per square mile of habitat this area appears underpopulated.

Since the surveys of 1957 and 1962 were undertaken under excellent observation conditions, they may be comparable. If the total count in the Sandman Reefs area is projected forward at an increase of 5 percent per year (see Andreanof Islands) the estimated 1962 count would be 637. The aerial count of 1962 was 638 otters. The 1957 survey may have missed a number of otters in the Sanak Island area, since Lensink's (1958) figures when projected to 1962 at 5 percent per year fall short of the count obtained in 1962.

Shumagin Islands

This group lies 100 miles east of the tip of the Alaska Peninsula and reaches its southern extremity at Chernabura Island about 100 miles south of the Peninsula's south shore.

Sea otters apparently survived the 1741–1911 period of exploitation in the Shumagin area where offshore feeding areas offered them refuge. Japanese poachers worked the area until at least 1910. An estimate of 4,000 otters in the southern Shumagins was made in 1920, but this population was certainly reduced when a tanker and a freighter were wrecked and spilled oil in this area during World War II (Kenyon, 1964).

A small human population lives at Unga Village on Unga Island and another at Sand Point on Popof Island. Reports from surface observers at these locations indicate that occasional otters wander to the vicinity of these two islands but that no sizable population exists there. About half of Unga Island was surveyed in 1962 and only four otters were seen, confirming reports of surface observers. The sea otter population of the outer Shumagins is, however, large (table 32). Many shallow areas with underwater reefs, particularly

BLE 32.—*Numbers of sea otters observed and estimated population in the Shumagin Islands*

Island	Aerial survey		1962 estimate of total
	1957 [1]	1962 [2]	
ga	2	4	8
gai	149	338	676
ar	3	14	28
rd	160	38	76
ernabura	132	79	158
neonof	455	294	588
tle Koniuji	430	255	510
Koniuji	220	222	444
ninsula	0	3	6
ectacle, Bendel, and Turner	268	105	210
pof (plus rocks)	2	—	4
dronica	1	—	2
ins	7	—	14
Total	1,829	1,352	2,724

Complete aerial survey, 20 to 24 July 1957 (Lensink, 1958).

Aerial survey, 10 April 1962, by D. L. Spencer and Kenyon. The survey of shallow areas shore was incomplete. Therefore all 1962 field enumerations are increased by a factor of 50 rcent to obtain the estimated total. If Lensink's 1957 count is used, the estimated total in it year is 2,440 (assuming 75 percent were seen). If population growth is considered to be ercent per year the 1962 population was 3,045 otters based on Lensink's field count.

tween Chernabura and Simeonof Island, furnish sea otter bitat well offshore.

Surface observations at Simeonof Island between 4 and 10 ne 1960 did not give an adequate indication of the number of a otters inhabiting this area. On 8 June a dory survey around meonof Island yielded a count of only 75 adult otters.

When the aerial observations of 1957 and 1962 are compared able 32) it appears that many of the 1962 counts are substantially less than those obtained in 1957 (Lensink, 1958). I lieve that, because of the very calm weather conditions prevailing before and during the 1962 survey, many otters had moved shallow offshore feeding areas, as they were observed to do in ne 1960, and were thus not seen. Lack of time prevented a mprehensive survey in 1962 of rather large offshore shallow eas.

U.S. Coast and Geodetic survey charts indicate that water depth not known in much of the Shumagin Islands area. A careful easurement of available sea otter habitat could therefore not made. The available soundings suggest that large shallow areas ist. I have estimated that about 700 square miles of habitat are ailable around the islands and that in 1962 the population nsity was about four otters per square mile of habitat.

laska Peninsula

The south shore of the Alaska Peninsula, which offers considerable sea otter habitat, extends for over 400 miles from False

Pass to Cape Douglas at the mouth of Cook Inlet. The north shore of the peninsula is discussed under "Unimak and Amak Islands."

D. L. Spencer has flown over the coastal waters of the peninsula many times. Because of his previous knowledge of sea otter distribution and because of a shortage of time, our 1962 survey included primarily those areas where a significant number of sea otters was known to exist.

Otters were counted in the Cape Kumliun–Sutwick Island area in 1951 and 1957 (table 33). This area appears to be the center of the population along this coast. The 1962 survey was made from Cape Kumliun northeastward. The greatest concentration of sea otters was in Kujulik Bay and around Sutwik Island. One large group which was photographed (fig. 70) contained 440 otters, by a count from the photograph, the largest assemblage that was seen on the aerial surveys up to that time. From this area northeastward the number of otters seen decreased as shown in table 33. In 1957 Lensink (1958) found none east of Chiginagak Bay. Our observation of five otters east of this point in 1962 indicates a slow population spread eastward.

The difference in distribution of otters in the area between Cape Kumliun and Cape Kunmik, including Sutwick Island, between the 1957 and 1962 surveys, probably indicates that this rather large local population shifts about in this area in response to weather or food supply.

It is not possible from available charts to measure the square miles of sea otter habitat along the southeast coast of the Alaska Peninsula. We believe, however, that the increasing population may fill much vacant habitat in future years before maximum population is reached.

TABLE 33.—*Numbers of sea otters observed and estimated population along the Alaska Peninsula*

Area	Surveys			Estimate of total [4]
	1951 [1]	1957 [2]	1962 [3]	
Univikshak Island area	13	180	86	143
Kujulik Bay (C. Kumlik)	12	103	684	912
Sutwick Island area	355	581	109	145
Aniakchak Bay and Amber Bay (C. Kunmik)	8	6	47	78
Cape Kunmik to Cape Igvak (55 miles)		19	22	37
Cape Igvak to Cape Kuliak (70 miles)		0	1	2
Total	388	889	949	1,317

[1] Aerial surveys during the May to August period by R. D. Jones (*in* Stiles, 1953).
[2] Aerial survey, 25 July 1957 (Lensink, 1958).
[3] Aerial survey, 10 April 1962, by Kenyon and Spencer.
[4] Estimated population as of April 1962.

odiak Island to Cook Inlet Area

From the Trinity Islands, off the south shore of Kodiak, to the arren Islands, in the mouth of Cook Inlet, is about 180 miles.

Records of confiscated sea otter skins in reports of the U.S. ureau of Fisheries (1912 to 1936) and the observation of four tters near Afognak Island in 1922 (Eyerdam, 1933) indicated at sea otters survived after 1911 in the Kodiak area.

Lensink (1958; 1960; 1962) conducted both aerial and surface rveys in this area and reviewed the numerous reports available om various individuals who lived in or visited the area during a eriod of many years. The historical record of 18th and 19th ntury otter hunters, as well as midden excavations reported by aughlin (1963), reveal that the sea otter was once numerous in e Kodiak area. Today repopulation is proceeding slowly. The ajority of observations of otters come from waters off the north ast of Afognak Island and nearby Shuyak Island or from the arren Islands. Lensink (1958) says of the few Kodiak Island ports that "The observations of otters on Kodiak are believed to e stray animals from the Shuyak area."

During the 1957 surveys Lensink did not find otters in the rinity Islands but reports that R. Lopp observed 14 in 1957 Lensink, 1958). The results of surveys by Lensink and W. Troyer re shown in table 34. D. L. Spencer has flown over and visited on e ground much of the coastal Kodiak area in recent years. He ld me in 1962 of reports from many local inhabitants. These all dicate that the Kodiak area has not been repopulated to a signif-ant degree.

On the west side of Cook Inlet, in Kamishak Bay, Spencer (letter, 957) observed 40 otters at Augustine Island and one at Shaw land.

enai Peninsula, Prince William Sound, and Kayak Island areas

The distance from the tip of the Kenai Peninsula to Kayak

ABLE 34.—*Numbers of sea otters observed and estimated population in the Kodiak Islands*

ata for 1957 and 1959 are from Lensink (1962), except the estimates based on field observations; 1965 data is from aerial survey by Spencer and Kenyon]

Island	Survey date	Otters observed	Estimate of total
gustine and Shaw Islands and Cape Douglas area	April 1965	120	200
rren	July 1959	272	363
uyak	July 1959	395	527
inity	July 1957	14	28
Total		801	1,118

Island off the coast is about 250 miles. Sea otters are scarce along the coast of the Kenai Peninsula. The center of the sea otter population in this area is in Prince William Sound.

Many reports of otters, particularly from Prince William Sound, were made during past years by personnel of the U.S. Fish and Wildlife Service, the Alaska Department of Fish and Game, and the U.S. Coast Guard (Lensink, 1962). That the population is a long-established one is indicated by the seizure by the Government of two illegally taken skins at Seward in 1924 (U.S. Bureau of Fisheries, 1925).

Aerial surveys made in 1959 by Lensink (1962) furnish the best modern information on sea otter populations in this region (table 35). We did not conduct an aerial survey of the Kenai Peninsula but a number of biologists have visited this coast. The lack of sea otter observations by them and by residents indicates that no significant population of otters occupy this area.

The long-established Prince William Sound sea otter population may have reached maximum size some years ago followed by a decrease in recent years, or, possibly the surveys are not comparable (table 35). The reason for the indicated decline is a matter of speculation. It may be that ecological conditions are marginal. Much of the coastal area is precipitous, furnishing only a narrow zone of shallow water where sea otters may obtain food. The Prince William Sound population, being the most northerly in Alaska, may suffer during severe winter weather. Available food species may be heavily infested with parasites to which the sea otter is poorly adapted. F. H. Fay found an individual more massively infested than any animals taken from other areas (see Parasites and Miscellaneous Diseases). Lastly, it is possible that the relatively

TABLE 35.—*Number of sea otters observed and estimated population in the Kenai Peninsula, Prince William Sound, and Kayak Island areas*

Area	Aerial survey observations		Estimated populations	
	1959 [1]	1964 [2]	1959 [3]	1964
Kayak-Wingham Islands	138	24	184	40
Hinchinbrook Island	58	167	93	223
Montague Island	349	42	465	70
Green and Little Green Islands	42	116	70	155
Latouche and Erlington Islands	87	1	145	2
Other, including unsurveyed areas	28	42	47	70
Total	702	392	1,004	560

[1] Data from aerial surveys made in April and August 1959 using a Cessna 180 aircraft.

[2] John Vania, letter of 30 October 1964. Aerial surveys made 1 and 2 October 1964.

[3] Estimates, although similar to Lensink's estimate of 1,000 to 1,500 (1962), are not taken from his report. For the sake of uniformity in this report they were computed on the same basis as other estimates.

rge human population of the Kenai Peninsula and Prince William
ound area may in some way inhibit sea otter population growth.

The Prince William Sound area was greatly affected by the
arthquake of 27 March 1964. An expedition to discover the effects
f the earthquake was undertaken by the U.S. Geological Survey
May and June 1964. An indication of the damage to some of
e sea otter habitat is told in letters of 4 June and 20 July 1964
om Dr. G. Dallas Hanna who was a member of the expedition.

> The destruction of animal and plant life in the former intertidal zone
> here we have been is catastrophic. Not a living thing is left on the upraised
> ction. I think it will be many years before a new zone is formed.
>
> Sea otters have been the most common of the marine mammals thus far.
> sually we are in small boats close in shore or on land in daylight hours and
> portunity for observation has not been the best. . . . Where the rise was
> eatest (7 to 33 feet) the kelp beds were destroyed so the animals seem to
> nge out in the channels.

Dr. Hanna recorded 70 otters observed by himself and other
embers of the expedition in the vicinity of Hinchinbrook, La-
uche and Montague Islands.

Further studies will be required to determine if the reduced
umber of sea otters observed in 1964 (table 35) was related to
e March 1964 earthquake.

Earthquake caused disturbances have drastically affected sea
ter populations. Voronov (1967) observed starvation and changes
distribution of sea otters in 1963 and 1964 following massive
struction of bottom fauna by tsunami in the Kuril Islands.

ribilof Islands

The sea otter was numerous at the Pribilofs at the time of their
scovery in 1786. Elliott (1875) says—

> en the Prybilov Islands were first discovered, two sailors, Lukannon and
> aiekov, killed at Saint Paul's Island, in the first year of occupation, *five*
> *ousand;* the next year they got less than a *thousand*, and in six years after
> t a single sea otter appeared, and none have appeared since.

Lutke (1835), however, indicates that in the first 2 years
a. 1786–88] the take was "plus de 200 loutres" and by 1828
l n'y eut bientot plus une seule loutre." The number taken during
ribilov's short visit to the Pribilof Islands is given by Nozikov
194?) as 2,325.

I. Veniaminov (*in* Elliott, 1875) indicates that the species was
t exterminated at the Pribilofs until about 1840. Records of the
ghting of two sea otters and of "one which had been crushed
the ice" in 1889 and 1896 are recorded by Preble and McAtee

(1923). As previously suggested (Lensink, 1960) these may have reached the Pribilofs on drifting ice from the Unimak–Amak Islands area. Preble and McAtee (1923) mention the finding of skulls in subsequent years. I presume that these, like the ones several other biologists and I have found since 1947, had remained buried under sand dunes since the 1700's or even earlier.

The area of available feeding habitat—water 30 fathoms or less in depth—around St. Paul Island is about 395 square miles. If the population there was as dense in 1786 as that now found at certain of the Rat and Delarof Islands (about 16 to 19 otters per square mile), the total population at the Pribilofs could have been about 6,300 to 7,500 in 1786. This estimate indicates that Elliott's (1875) statement is plausible.

In April 1954 we attempted to transplant sea otters by ship from Amchitka Island to the Pribilofs. All 19 animals apparently died soon after liberation on 9 April. None was subsequently seen. Another transplant of seven otters by aircraft on 20 May 1959 was successful in that at least some of them survived. Residents of the Pribilof Islands, believed to be reliable observers, reported the occasional sighting of one or two otters until the spring of 1961. Although the sightings could not be verified, they do indicate the possibility that at least some otters survived for 2 years (see Transplant Attempts).

Isolated as this island group is by 240 miles of open sea from the nearest population, near Unimak and Amak Islands and the tip of the Alaska Peninsula, there is probably little chance that natural repopulation will occur in the near future. The possibility exists that eventually otters associated with floating ice may reach the Pribilofs from the Unimak-Amak-Alaska Peninsula area.

Other western Alaska areas

The Pavlov Islands (55° N. lat., 161°30′ W. long.) are south of the Alaska Peninsula and northeast of the Sandman Reefs. In 1957 (Lensink, 1958) and again in 1962 the group was partially covered during aerial surveys. On each survey four otters were seen near outer Iliasik Island. As the Sandman Reefs population grows, otters will probably move from that area into the Pavlov Islands.

The Semidi Islands (56°10′ N. lat., 156°45′ W. long.) lie about 20 miles south of Sutwik Island. In the summer of 1957 Lensink (1958) recorded five otters there. This isolated group was not subsequently surveyed.

Chirikof Island (55°50′ N. lat., 155°35′ W. long.) is about 40 iles southwest of the Trinity Islands and was not included on a otter surveys. D. L. Spencer told me in 1962 that he flew ound Chirikof and saw no sea otters there.

outheastern Alaska

Observers occasionally report sea otters from the vast complex islands, passes, and straits of Southeastern Alaska. Enforceent Agent J. A. Klingbeil, Jr., (letter, 14 October 1950) reported ur animals seen at Nakwasina Bay on 2 September 1950, which believed to be sea otters. He also reported a single otter seen Silver Bay, Baranof Island (*in* Lensink, 1958). The possible servation of sea otters near Ketchikan was reported by J. itcher in 1945 (*in* Lensink, 1958) and by L. W. Croxton in 1961 etter, 1962). No observation, however, has been confirmed by her observers. It appears that until 53 were transplanted to e area by the Alaska Department of Game in 1965 and 1966 few, any, sea otters existed in Southeastern Alaska.

Dall (1870) indicates that exploitation of the sea otter in the lexander Archipelago was intensive. Apparently this population as wiped out before 1900.

Maynard (1898) indicates that otters were most abundant long the coast as far as Sitka. South of that point they were less merous and were taken mostly from Queen Charlotte Islands."

There is no record that sea otters occured in the inland pasges of Southeastern Alaska and apparently they also shunned rts of the outer coast.

RITISH COLUMBIA

The sea otter apparently became extinct on the British Columbia ast during the 1920's.

In a conversation, in 1962, A. W. F. Banfield told me of a sea ter skull, deposited in the National Museum of Canada, that was und by Patch in the Queen Charlotte Islands in 1919. Later he rote (letter, 1963):

> iscussed the specimen with [C. A.] Patch some years ago and was under e impression it was a fairly fresh skull, when he picked it up. . . . The tional Museum of Canada sponsored an expedition to the north end of aham Island during the summer of 1919. . . . Concerning the sea otter [Patch, 1922] writes (p. 103): "I found a sea otter skull in a deserted bin near Rose Spit. Chief Harry Wiah said that about a year before our visit Indian shot at a sea otter which was resting on kelp near North Island. also said that about thirty years ago his father, his wife's father and er Indians—a total of nineteen boats—got twenty-one sea otters in a renoon and six in the afternoon.

The most recent record is of a sea otter taken at Grassie Island, Kyuquot, in 1929 (Cowan and Guiguet, 1956). Concerning this specimen Guiguet wrote in a letter (1958) that—

> We have one specimen record (skin) of an adult sea otter taken at Kyuquot Sound (Grassie Island) in the autumn of 1929 and donated to the Provincial Museum by the B. C. Game Commission. There are few details, the animal was not sexed, measured or the skull preserved. Since that time we have no authentic report, but many "sight" records, and of those investigated all proved to be river otter. . . . As far as we know, the sea otter has yet to re-establish on the British Columbia coast.

WASHINGTON

The last authentic record of sea otters on the Washington coast is of "several" being killed at Willapa Harbor in 1910 (Scheffer, 1940).

The river otter is frequently seen in salt water along the outer coast and among the islands and inland waterways of Washington State. Observers often report these to us as sea otters. To date, all sightings that could be investigated proved to be of river otters. C. Vandersluys of Friday Harbor, Wash., who is familiar with the inland waters, wrote (letter, 1963):

> We did see a group of otter last summer, off the San Juan Islands. In fact, this animal seems to be increasing in number in this area each year. Locally we call them land otter, and to my knowledge, I have never seen a sea otter around here.

I have searched the outer coast of Washington many times during the past 10 years but have never confirmed any report of sea otters there (Kenyon and Scheffer, 1962).

Although originally numerous on the outer coast of Washington, it is doubtful whether the sea otter ever occurred on inland waters at any distance from the open-sea coast. Scheffer (1940) says, "There are no authentic records of the sea otter in Puget Sound or the San Juan Islands." Dr. E. Gunther (letter, 1963) told me:

> Peter Puget's Journal of the exploration of Puget Sound, May 7 to June 11, 1792 [from] Pacific Northwest Quarterly, vol. 30, no. 2, April 1939 . . . commented on the absence of sea otters in Puget Sound (p. 200). . . . [From] Menzie's Journal of Vancouver's Voyage: "We saw but few sea otter skins amongst them [the natives] which shows that these animals do not much frequent the interior channels."

Dr. R. E. Greengo, Professor of Anthropology at the University of Washington, told me in 1963 that he and his students have carefully examined about 30 midden sites in the Puget Sound area. Among the many bones found, only two, from Sucia Island in the

an Juan group, were from the sea otter. Comparison with speci-
ens in the U.S. Fish and Wildlife Service collection showed them
be phalanges, one from a front and one from a hind paw (Uni-
ersity of Washington collection no. 455J105). Dr. Greengo esti-
ates that the remains were deposited at the site 1,500 years ago.
ea otter bones occur quite frequently in midden sites on the outer
oast of Washington. It appears that during the time of human
ccupation, the sea otter was extremely scarce or absent within the
nclosed waters of Puget Sound. Certainly the "great numbers of
ea otters" in the Columbia River as far up as Celilo Falls recorded
y Lewis and Clark (see Burroughs, 1961) were not sea otters but,
s Bailey (1936) and Scheffer (1964) point out, harbor seals
Phoca vitulina).

REGON

Bones found in middens along the Oregon coast indicate that
he sea otter was once abundant there, but Bailey (1936) records
hat after 1876 the species was not again reported from Oregon.
Irs. V. F. Martin (letter, 12 August 1965) told me of an uncon-
rmed report that may represent the last of the original sea otter
opulation in Oregon:

> answer to my query to Otter Rock, Oregon, a correspondent (signed C.
> ones) wrote me on July 29, 1965: "Frank Priest of Newport, Oregon (now
> eceased) told me several years ago that the last otter taken here was by
> and Joe Biggs (deceased) of Agate Beach, Oregon. That was in the year of
> 06, and they sold it for $900,00. (Rich Chinese in San Francisco were the
> ter buyers for local people.)"

A recent sighting about 30 miles north of Tillamook Bay, near
eahkahnie, at about 45°44′ N. lat. (Pedersen and Stout, 1963)
as not been confirmed by other observers.

It is a matter of speculation that occasional otters may wander
own the coast from Prince William Sound, as far as the outer
oast of British Columbia, Washington, and Oregon, or that stray
nimals move northward from the well-established California
opulation. A linear distance along the Pacific Coast of approxi-
ately 2,000 miles separates the sea otter colony at Kayak Island,
laska, from the central California population.

ALIFORNIA POPULATION

Although reports of fish and game wardens recorded the con-
nual presence of a small herd of sea otters during early years of
e present century, it was not until 19 March 1938 that their

presence near the mouth of Bixby Creek, Monterey County, became generally known (California Senate, 1965).

The permanent population of sea otters on the California coast is between Point Conception (34°27′ N. lat.) and Monterey Bay (36°33′ N. lat.). Here, during an aerial survey on 27 August 1957, Boolootian (1961) observed 638 otters. Because of predation by the sea otter on abalones *(Haliotis* sp.) the opinion was expressed that sea otters were shot or killed with spears by fishermen (H. Shelby, *in* California Senate, 1963). To ascertain the number of otters presently on the California coast, aerial surveys were conducted by the California Department of Fish and Game. The surveys included the areas surveyed by Boolootian (1961). During the first, 26 to 29 January 1964, 236 otters were observed (Commercial Fisheries Review, 1964a). During the second, 13 February 1964, the counts by two observers were 339 and 351 (Commercial Fisheries Review, 1964b). The most recent survey was on 8 June 1966 when 618 otters were counted (J. G. Carlisle, Jr., letter, July 1966). [For recent information see page 200 and footnote 5, table 36.]

These surveys indicate that the California sea otter population has not increased in recent years. Other observations, however, suggest that the population in the area surveyed did not increase because otters wandered to other areas.

R. G. Prasil searched National Park Service files on the Channel Islands and found the following reports (J. C. von Bloeker and R. M. Bond, letter 28 May 1940):

> Kenneth E. Stager saw a sea otter asleep in the rocks on the northwest side of Santa Barbara on March 17th [1940]. He approached to within 30 feet of it before it awakened and took to the water. He is familiar with these animals off the Monterey County coast (as I am also) and I see no reason to doubt his record.

Another report was obtained by L. Sumner and R. M. Bond (letter) during a survey at Anacapa Island in 1950. They interviewed a long-time island resident named Raymond (Frenchy) Ladreau and wrote:

> Ladreau told us that in 1943 two sea otters came to the kelp beds of the West Island and to the landing area nearby where he has his shack. He said they were quite tame and unafraid and remained there for 2 or 3 days before disappearing. This is the second recent record of sea otters in the Channel Islands area and indicates that if undisturbed they may be expected to increase in that general region. Perhaps some day, if protected from poachers, they will remain permanently around Anacapa and neighboring islands.

Allanson (1955) reported seeing two otters at San Miguel Island in the Channel Islands (34° N.) in 1954.

On 17 and 18 March 1958, I visited Santa Rosa and San Miguel slands aboard the M/V *Trinity* and observed the inshore waters f both islands from a dory. Much ideal sea otter habitat was xamined but no otters were seen. This survey and reports from ther visitors to the Channel Islands indicate that, as yet, no ubstantial sea otter population has developed there.

Orr and Poulter (1964) recorded several observations at Año Nuevo Island (37°7′ N. lat.) in the summer of 1963; and Bentley 1959) noted two near Trinidad Head (41° N.) in December 1956, ndicating that individual otters are moving northward.

OWER CALIFORNIA, MEXICO

The aboriginal population of sea otters reached its southern limit t least as far south as Morro Hermoso (27°32′ N. lat.) (Ogden, 941) and Natividad and Cedros Islands (27°50′ N. lat.) (Anhony, 1925; Scammon, 1870). Anthony indicates that the last emaining colonies "in the region of certain kelp beds south of nsenada" were wiped out when about 50 were killed in 1897 nd an additional 28, "eight or nine years later at the same point." he last record he gives is of one being "killed by fishermen in 919, at San Benito Island."

In April and May 1946 and in January and February 1965 I isited many of the islands and inshore water areas along the oast of Lower California from Natividad Island to the U.S. border. found no information that sea otters might still exist along the oast and saw nothing to indicate their presence. The species was robably extirpated on the Mexican coast in 1919.

OVIET UNION POPULATIONS

Barabash-Nikiforov (1947) summarizes information on the disribution of sea otters in the Soviet Union. Information on modern ea otter populations in areas under Soviet control became availble only recently. The drowning of Scientist S. D. Pereleshin at aramushir Island in the Kuril Islands in 1959 probably retarded ea otter studies. Pereleshin's successor, Scientist A. N. Belkin, ccidentally shot himself in 1965 (pers. comm., V. A. Arseniev) ut some of his work was published posthumously.

ommander Islands

Data obtained on a visit to the Commander Islands in July 1961 nd the available published information is summarized.

Geologically the Commander Islands (Komandorskie Ostrova) are part of the Aleutian Chain. They are separated from Attu, westernmost of the Near Islands, by about 185 miles of open sea. Permanent human settlements are Preobrazhenskoe (population about 300) on Copper Island (Ostrov Medny) and Nikolskoe (population about 500) on Bering Island (Ostrov Bering).

Exploitation of the sea otter began at the Commander Islands in 1741 when Vitus Bering's second expedition discovered them. Barabash-Nikiforov (1947) stated that in 1902 the sea otter population there was "at least 2,000 head" but because of excessive killing "the herd numbered 700 head in 1904." The number at Medny "in the winter 1911–1912 . . . was 63 head." After 1924 he says that "Importation of animals was begun and still continues" and the number rose to "over 200 head in 1930." He also says that "An increase in the number of sea otters around Bering Island was observed after the autumn of 1931."

Information now available contradicts some of the data given by Barabash-Nikiforov (1947). The current information is presented.

Marakov (1963) says of the Commander Islands that the sea otter became rare early in the 19th century and then "disappeared entirely, first on Bering Island and then also on Medny Island." They reappeared on Medny toward the end of the century but have never reappeared on Bering Island. "Hunting continued on Medny Island until 1924. When it was completely banned, no more than 350 individuals were left." The herd showed little or no increase during the following 30 years. Marakov believes that various human activities, including the spilling of petroleum products in the sea, prevented population growth. Marakov (1965) states that "the herd of otters on Medny Island numbers more than 1000 adult individuals."

I obtained additional information during a visit to the Commander Islands from 9 to 23 July 1961.

We saw six sea otters (five adults, one pup) during our visit. We found these near the southeast end of Medny Island along about 3.5 miles of coast. Reefs projecting from the shore, outlying rocks, and extensive kelp beds provide excellent habitat in this area. The green sea urchin is abundant at the locations we visited on Medny and Bering Islands. Two sea otter droppings found among the rocks at Medny consisted entirely of sea urchin tests.

Certain of our hosts, the late Dr. S. V. Dorofeev, G. A. Nesterov (biologist), and E. P. Skripnikov (supervisor of sealing activities at Medny and a resident of the Commander Islands for about 25 years—15 years on Bering Island and 10 years on Medny Island) ave us the following information: Hunting of sea otters at the ommander Islands continued until the 1917–22 period. By that ime, when protection was enforced, otters had been extirpated t Bering Island. They have never become reestablished there.

Sea otter studies were carried on at the Commander Islands by arabash-Nikiforov during the late 1920's. The animals were aptured in nets set in the water and were held captive for study urposes. During the 1950's, Biologist Fedorof and Scientific Vorker Danielov held a male and female captive on Bering Island. he animals were captured at Medny.

uril Islands and the Kamchatka Peninsula

In 1943 Nikolaev (1961) estimated that the sea otters in the amchatka Peninsula area numbered about 300, and Klumov 1957) estimated from field observations made in 1951, 1955, and 956 that the Kuril Islands population numbered "at least 1,500 ead." Belkin (1966) reviews various studies of sea otters in the uril Islands and presents the results of his own work from 1962 1964. His count of otters at 22 islands yielded a total of 4,300 nimals (3,300 adults and about 1,000 young).

VORLD POPULATION

The preceding sections present the data on the world population f sea otters that were gathered during a period of many years. he most recent estimates derived from field observations, when rojected at the observed growth rate (for those populations still rowing) of one population (about 4 to 5 percent per year), give computed estimates of about 33,000 sea otters (table 36) extant the world in 1965.

On the basis of the historical record and field observations preented in foregoing pages, it appears that sea otters survived at e close of the 1741–1911 period of unregulated exploitation in e following 11 geographical areas: (1) Kuril Islands, (2) Kamatka Peninsula, (3) Commander Islands, (4) Rat Islands, (5) ndreanof Islands, (6) The Unimak and Sanak Islands-Sandman eefs area, (7) Shumagin Islands, (8) the Kodiak to Prince illiam Sound area, (9) near Monterey, Calif., (10) the Queen harlotte Islands, British Columbia, and (11) the San Benito lands, Baja California. From the last two locations, however, ey were soon extirpated.

TABLE 36.—*Estimated world population of sea otters*

Area	Date of observation	Sea otters observed	Estimated total [1]	Estimated total in 1965 [2]	Authority
Soviet Union:					
Kuril Islands Kamchatka	1962–64	(?)	4,300	4,700	Belkin (1966).
Medny Islands	(?)	(?)	1,000+	1,200	Marakov (1965).
Alaska:					
Near Islands	1965	[3] 27	45	45	FWS aerial surveys.
Rat Islands	1965	[3] 3,147	4,196	4,196	Do.
Delarof Islands	1965	[3] 653	871	871	Do.
Andreanof Islands	1965	[3] 5,805	7,760	7,740	Do.
Fox Islands	1965	[3] 2,935	3,913	3,913	Do.
Sanak-Sandman Reefs	1962	[4] 1,186	1,625	1,880	Do.
Shumagin Islands	1957	[4] 1,829	2,724	3,972	Do.
Pavlov Islands	1962	[4] 4	8	10	Do.
Semidi Islands	1957	[4] 5	10	16	Lensink (1958).
Alaska Peninsula	1962	[4] 949	1,317	1,525	FWS aerial surveys.
Prince William Sound	1959	[4] 702	1,004	1,004	Lensink (1962).
Kodiak Island area	1957–59	[4] 722	973	1,237	Do.
California [5]	1966	618	600	600	J. G. Carlisle, Jr., letter, 1966.
Total		18,582	30,346	32,909	

[1] At time of observation.

[2] Projected from the year of the original estimate on the basis that in underpopulated areas growth will be at the rate of 5 percent per year. Where field observations indicate that little or no growth is occurring, no projection of growth is shown.

[3] Aleutian Islands total is 12,567. This also includes S.W. Bristol Bay.

[4] Total 5,397. The total for all of Alaska is 17,964 (5,397 + 12,567).

[5] In a series of aerial and surface censuses begun in August 1968, the highest count of sea otters was 1,014 (Peterson and Odemar, 1969).

ISCUSSION

In the foregoing section, observations of sea otter populations
tained between 1935 and 1965 in several geographic areas were
viewed. The data included aerial and surface counts, total
pulation estimates based on them, measurements of available
bitat, and population densities in different areas. The field
servations and the conclusions derived from them are discussed
low.

ate of population increase

Two methods may be used to ascertain the approximate rate of
crease in a sea otter population: (1) The annual rate of repro-
ction and mortality in a population may be studied; or (2) otters
an isolated population may be counted at intervals and the
crement found directly. The first method is treated elsewhere.
he results obtained by the second method are discussed below.

Because movements of large numbers of otters from one island
another were recorded, it was evident that the area included
population surveys must be sufficiently large to include locations
here both emigration and immigration occurred. The population
rveys in the Andreanof Islands furnish the best available in-
rmation on which to base a study of population growth. On the
st, this otter population is isolated from the small population of
e Umnak-Samalga Islands by 120 miles, which includes Amukta
ss and the unpopulated Islands of Four Mountains. On the west,
e study area is separated from the Delarof Islands by 14-mile-
ide Tanaga Pass.

This sample area, about 210 miles in length, includes densely
pulated islands adjacent to others having unoccupied habitat.
erial surveys of the Andreanofs in 1959, 1962, and 1965 were
nducted under comparable conditions by the same observers.
he small, semi-isolated populations at Atka and Amlia at the
stern end of the sample area showed a larger rate of increase
an did the total Andreanof population. Probably these colonies
ere augmented by wandering individuals that formed the van-
ard of the massive eastward moving population of the Kanaga-
dak-Kagalaska Islands segment of the sample area.

The rate of the Andreanof population increase of about 12 +
rcent in each of two 3-year periods or over 4 percent per year,
less than the rate of increase postulated by Soviet biologists.
he rate of increase was at first presumed to be 10 to 12 percent
r year by Barabash-Nikiforov (1947) but he finally concluded
at this rate was not in accord with his field observations and

placed the annual rate of increase of a population at 7 percent. In the Commander Islands, however, even this rate appeared somewhat high when compared with his "on the spot observations." Lensink (1962), on the basis of his surveys, concluded that the rate of increase of the Andreanof Islands population was 10 to 15 percent per year. The more comprehensive data gathered in the same areas after his studies were completed, however, indicate that the total population within the Andreanof group is now increasing at a lower rate, probably because of density-caused mortality in the heavily populated areas.

In a local area of sparse population, the 1959–65 data indicate the population may have increased during that period at an annual rate of at least 10 percent. For example, the estimated population at Seguam, the easternmost island of the sample area, increased from 28 to 47 otters (table 25) in the 6-year period 1959–65 or at a mean annual rate of a little more than 11 percent. This conclusion is based on the assumption that Seguam Pass is a fairly effective barrier to immigration.

After a large population is produced, as it was, for example, at Adak (in the Andreanof Islands) in the 1954–62 period (table 28), the overall annual increase of the Andreanof population was at the rate of about 4 percent.

The observed 4 percent annual rate of increase is a generalized figure. At islands where the population exceeded the carrying capacity of the habitat, i. e., more than 10 to 15 otters per square mile of habitat (see table 25), population regression was observed. Stress mortality (starvation), as well as emigration, probably accounted for the local population decreases. Evidence to support this view was found on 28 April 1965 during a brief examination of one otter hauling ground at Shagak Bay, Adak. There I found a large juvenile otter dead on the beach. It exhibited all the characteristics of starvation that I observed at Amchitka. Probably the rate of mortality during the winter-spring season of stress at Tanaga, Kanaga, and Adak in the 1962–65 period was considerably greater than at the relatively sparsely populated islands east of Kagalaska during this same period.

Thus, the rate of population increase varies according to population density and its relation to ecological conditions and may be quite different from the rate of reproduction. Elsewhere it is shown that about 16 young may be born annually per 100 independent animals of both sexes and all ages.

In general, it is concluded that an isolated population having ample unused habitat may grow through local reproduction (no ımigration) at a rate of about 10 to 12 percent per year. In a gion that includes both densely populated areas (where winter-ring mortality occurs) and adjacent unpopulated habitat, the te of growth may be about 4 to 5 percent per year.

ptimum population density

No study has yet been undertaken to indicate the productivity the sea otter habitat or to show what critical differences in food oductivity exist in different habitats. Because such studies are t available it is not possible to compute, on the basis of food sources available, the number of sea otters that any particular bitat may support.

On the basis, however, of the observed behavior of several island pulations of sea otters it is possible to reach tentative con-ısions as to the approximate optimum population density and ıich areas are overpopulated or underpopulated.

At five locations (Rat, Amchitka, Tanaga, and Kanaga Islands, d the Delarof group) we observed large otter populations which bsequently became greatly reduced (table 37 and fig. 78). The ures available do not necessarily represent absolute maximum d minimum populations because of the infrequency of observa-ns. From these data it appears, however, that a growing sea ter population in an unexploited habitat may reach a temporary aximum density of 40 or more animals per square mile of habitat. ter such a high density is attained, a period of population re-ction occurs, either through emigration, a high rate of mortality, both concurrently during seasons of stress. That a depleted eding habitat may support about 10 to 15 otters per square mile indicated by the observation that the five densely populated eas dropped to that level.

TABLE 37.—*Changes in sea otter population density in six areas*

Island	High population		Low population		Interval years	Means of reduction [2]
	Date	Number [1]	Date	Number [1]		
:	1943	31	1949	10	6	Mortality (?).
chitka	1943	41	1949	13	6	Mortality
arof	1959	21	1965	10	6	Mortality (?).
ıaga	1953	(3)	1959	14	6	Emigration.
ıaga	1959	26	1962	12	3	Emigration
ık	1962	40	1965	24	3	Emigration and mortality
Mean		30		12		

Otters per square mile of feeding habitat (waters 30 fathoms or less in depth).

It is known that emigration took place because rapid population increase in nearby areas observed. Mortality was observed and documented only at Amchitka. At Rat Island and in Delarofs a condition similar to that at Amchitka would be expected.

Unknown but presumed to be high on the basis of reports that otters there numbered in the usands (Hooper, in Jones, 1953, Lensink, 1960).

The Kanaga data indicate that this level may be maintained fo at least a 3-year period. The Amchitka data indicate that after th initial population "crash" a period of slow increase, or adjustment, occurred (table 23). During the recovery period the population approached a density of about 20 otters per square mile o feeding habitat. That this is not an optimum population density i indicated by the continued annual occurrence of heavy mortalit among juveniles and old adults (see Age Specific Mortality), b comparatively small body size (see Body Measurements), by excessive dental attrition, and by the fact that by 1965 the populatio had fallen to a density of 14 otters per square mile of habitat.

Optimum population density in the Aleutian area, after a depleted habitat has recovered from the damage caused by overutilization of food resources, may be postulated at about 10 to 1 otters per square mile of habitat. Table 38 shows predicte populations in certain Alaska areas based on data now available More data are needed, however, to properly estimate optimun population density.

Geographic barriers

Passes between areas of feeding habitat around islands, ma act to a varying degree as barriers to the spread of sea otte populations. For example, Buldir, Semisopochnoi, and the Nea Islands were not repopulated for a number of years after th islands nearest to them supported high populations. The 55 mile of open water between Buldir and Kiska was an effective but no a permanent barrier. A few otters reached Buldir from Kisk betwen 1936 and 1961. Kiska was densely populated by 1959 an perhaps before that, but not until the 1959–65 period were smal colonies established in the Near Islands, 65 miles west of Buldir.

TABLE 38.—*Present and projected sea otter populations in certain Alaska areas*

[Only the areas that have been most intensively studied are included. The projections of future populations are based on the assumption that a population of about 10 to 15 otters per square mile of feeding habitat may be supported]

Area	Square miles of habitat	Projected total number of sea otters	Present population estimate
Near Islands	326	3,300– 5,000	27
Rat Islands	293	3,000– 4,400	4,200
Andreanof Islands	766	7,700–11,500	7,800
Delarof Islands	89	900– 1,300	930
Islands of the Four Mountains	88	900– 1,300	0
Fox Islands	570	5,700– 8,500	25
Krenitzen	200	2,000– 3,000	55
Unimak-Amak Islands	1,000	10,000–15,000	4,000
Sanak Island and Sandman Reefs	900	9,000–13,500	1,600
Shumagin Islands	700	7,000–10,500	2,700
Total	4,932	49,500–74,000	21,337

The 30 miles of deep open water between Amchitka and Semi- opochnoi Islands was apparently a less effective barrier. No otters ad reached Semisopochnoi in 1943 (when the Amchitka population as near maximum size) but by 1959 the population at Semi- opochnoi was relatively dense (16 otters per square mile). Move- ent to Semisopochnoi of a substantial number of otters, rather an the slow increase of a small breeding nucleus, during this eriod is indicated.

he behavioral barrier

Considerable data show that the reoccupation of vacant habitat dependent to an important degree on the inherent behavioral haracteristics of the sea otter.

The sea otter does not undertake seasonal migrations. Recovery f marked sea otters at Amchitka revealed that the home range f an individual otter includes only a few miles of coast. Marakov 1965, p. 212) also found that otters in the Komandorski Islands ecome attached to a particular area.

Elsewhere (see Amchitka Island) it is shown that otters move nto areas of nearby but unoccupied habitat only in response to population pressure" after a large local population has developed table 23). The Amchitka data indicate that the remanent colony hich repopulated the island was probably on the Pacific coast nd that significant numbers of sea otters did not move to the ering Sea coast until 1940 or soon thereafter (fig. 73).

Substantial population movement from densely populated anaga to nearby unpopulated Adak and later from Adak to earby islands east of it did not occur until dense local populations uilt up. In 1959 the Adak population had reached a density of 1 otters per square mile of habitat (table 28) but only one otter as observed at nearby Kagalaska (table 29). It thus appears at otters tend to maintain an established home range until the ffects of a dense population force movement.

andering individuals

Many observations of individual otters at great distances from rge local populations are available. That such wanderers even- ually settle permanently in a locality that offers ideal habitat onditions is indicated by the existence of small colonies at great istances from large population centers. The small colonies found 1 the Near Islands, Buldir, Atka, Amlia, Seguam, and in the mnak-Samalga and Tigalda Islands areas in the 1950–65 period, re examples.

It thus appears that vacant sea otter habitat is repopulated by two means: (1) Movement of large numbers of otters from a densely populated area to adjacent unpopulated habitat, and (2) wandering individuals that accumulate to form colonies where habitat conditions are ideal many miles distant from dense populations.

Because of the indicated 4 percent per year rate of growth of the Andreanof sea otter population, the repopulation of vacant habitat at the periphery of a densely populated area, is, today, the most important means by which the sea otter is reoccupying the places from which it was exterminated during the 18th and 19th centuries.

Dispersal of sea otters and population density

Most animals included in tagging studies at Amchitka were adults when marked and the recoveries indicated that they remained permanently along a limited area of coast (see Home Range). By analogy with other species it would seem probable that wanderers, contributing to range extension, might be composed mostly of subadult animals. That this may be true also of sea otters is indicated by our failure to observe as many mothers accompanied by small young in newly populated areas as in other areas. In 1959, we saw no otters in Kagalaska Strait, but in 1962 we observed 348 there. Aerial photographs of a group of 157 animals and another of 59 revealed not one small pup among them. In mid-November of 1965, when this area was well behind the vanguard of population expansion, I spent 2 days in Kagalaska Strait and saw a number of mothers accompanied by young.

Two possible conclusions concerning the otters which first appeared in Kagalaska Strait are indicated: (1) All were males, and (2) they were mostly subadults of both sexes and had not born young.

Estimates of population density, or the number of sea otters per square mile of available habitat, were obtained in several Aleutian areas. Among these were locations where substantial populations have existed for many years, and also recently repopulated areas.

On the basis of geographical barriers and population density, sea otter populations in Alaska may be classified according to four general categories (two densities of isolated populations and two densities of populations adjacent to available habitat).

1. *Dense isolated populations*

This category includes populations of sea otters that have reached a size which heavily utilizes food resources in the available habitat. Significant population dispersal to new habitat is hindered by broad expanses of deep water which prevent feeding.

The Rat Islands (except Buldir Island) population is an example. Significant emigration of sea otters from this island group appears to be slowed by passes hundreds of fathoms deep and about 50 miles wide on the eastern and western extremities of the group. The average population density was about 14 otters per square mile of available habitat (table 21). When such populations increase and exceed the carrying capacity of the habitat, heavy mortality occurs because substantial emigration does not occur.

2. *Sparse isolated populations*

The recently established Buldir Island colony and the Samalga and Tigalda Islands populations are examples. Many years may elapse before these populations approach maximum size. The Samalga-Umnak population is separated from the nearest Andreanof population at Seguam by Amukta Pass, 35 miles wide, and by the Islands of Four Mountains, a total distance of 120 miles, where no otters are found. The Tigalda Island colony is about 140 miles east of Samalga. Such small colonies grow slowly because they are rarely augmented by immigrants.

3. *Dense local populations adjacent to areas of vacant habitat*

The Andreanof, Sanak, Unimak, and Shumagin Islands, and the Alaska Peninsula areas furnish examples of populations which today are large but may expand into adjacent vacant habitat. During aerial surveys, comparable observations of expanding distribution and increasing abundance of sea otters were obtained in these areas. Such populations expand rapidly because movement of part of the population increment to new areas is possible and minimum mortality probably occurs except at densely populated islands after they are left far behind the spearhead of population growth.

4. *Sparse local populations adjacent to areas of vacant habitat*

In the Aleutian Islands three local populations of sea otters—at Atka, Amlia, and Seguam Islands—are placed in this category. These populations occupy a tiny part of the habitat available to them. They are separated from other populations by many miles but not by geographical barriers. They may be augmented by an influx of otters from the western Andreanofs. Narrow passes between islands of this group are easily crossed.

The rate of increase of these three colonies is related inversely to their distances from the large western Andreanof population:

Colony	Distance from large population (miles)	Annual rate of increase 1959–62 (percent)	Annual rate of increase 1962–65 (percent)
Seguam	130	10	10
Amlia	100	12	13
Atka	60	30	85

Possibly the annual rate of increase of the Seguam colony represents the rate of increase that may be attributed to local reproduction in an uncrowded population.

Summary

1. In 1741 when unregulated exploitation of the sea otter began, the species ranged from central Lower California, Mexico, north along the coast of the North Pacific Ocean, through the Aleutian and Kuril Islands to the northern islands of Japan.
2. The northern limit of the sea otters' range overlaps but slightly the usual southern limit of winter drift or pack ice in the Bering Sea. The farthest north colony in Alaska is in Prince William Sound (60°30′ N. lat.) where the sea does not freeze.
3. The total population of sea otters in 1740 was probably between 100,000 and 150,000 animals.
4. The number of sea otters taken during 170 years of unregulated exploitation is not recorded but probably did not much exceed one-half million animals.
5. The total world population in 1911, when exploitation of the sea otter was halted, probably numbered between 1,000 and 2,000 animals.
6. Small sea otter populations apparently remained in 1911 at the following 11 areas: Kuril Islands, Kamchatka Peninsula, Commander Islands, Rat Islands, Andreanof Islands, the Unimak, Sanak Islands-Sandman Reefs area, Shumagin Islands, Kodiak Island and Prince William Sound area, in the Queen Charlotte Islands, British Columbia, on the coast of California near Monterey, and in the San Benito Islands, Baja California.
7. The first modern data on the recovery of sea otter populations were obtained in the Aleutian Islands in the mid-1930's and considerable miscellaneous data were subsequently gathered during the 1940's. Detailed field studies of population and distribution were begun by the Fish and Wildlife Service in 1954 and continued through 1965.

8. The sea otter is limited to a relatively narrow band of water around islands and along mainland shores where water depths do not exceed 30 fathoms. Under the prevailing weather conditions when aerial surveys were made, sea otters were easily observed. We concluded that in most areas about 75 percent of the sea otters present were recorded. Comparative surface and aerial surveys indicated that about 60 percent of the otters seen on an aerial survey may be missed on a surface survey.

9. Data obtained on aerial surveys in the Andreanof Islands in 1959, 1962, and 1965 indicated that in this area, having much available and unpopulated habitat, the population is growing at an exponential rate of between 4 and 5 percent per year.

10. Aerial surveys and other studies conducted between 1954 and 1965 in Alaska reveal that large areas of sea otter habitat are not yet repopulated. In certain areas repopulation of vacant habitat is proceeding rapidly (the Andreanof Islands). In isolated areas the habitat may be heavily utilized by a dense population (the Rat Islands).

11. In all observed areas where estimated sea otter populations reached 20 to 40 otters per square mile of habitat, the populations decreased to about 8 to 15 otters per square mile of habitat. The decrease occurred through mortality (e. g., Amchitka Island) or emigration (e. g., Kanaga and Adak). In years following a population "crash" the populations at islands may fluctuate between about 10 and 20 otters per square mile of habitat.

12. Reoccupation of available sea otter habitat is hindered by wide, deep passes between islands. Sea otters readily cross passes about 10 miles wide. Significant numbers may cross 30 miles of open water (e. g., Amchitka to Semisopochnoi). Passes 50 miles or more in width may be crossed by a few individual otters that wander great distances from densely populated areas (e. g., from Kiska to Buldir and from there to the Near Islands). These individuals may eventually concentrate in locations having unusually desirable habitat.

13. The most significant factor that limits the spread of sea otter populations is the tendency of individual otters to occupy a limited home range. Feeding habitat on one side of an island, or at an island near another having vacant habitat, may become densely populated (to about 40 otters per square mile of habitat) before a significant number of otters move into adjacent vacant habitat even at the home island. Where repopulation was observed, the south sides of islands were repopulated prior to the north exposures (e. g., Amchitka, Atka, and Amlia).

14. In addition to the many areas in western Alaska offering sea otter habitat which today is unpopulated, approximately 2,000 miles of coastline, including much sea otter habitat, separates the colony at Kayak Island, Alaska, from the small central California colony.

15. Several aerial surveys were made in 1958 and 1964 to 1966 along the California coast. The highest counts in 1958 and 1966 yielded 638 and 618 sea otters, respectively. Further surface and aerial surveys, begun in August 1968, yielded a high count of 1,014 otters (Peterson and Odemar, 1969), indicating a population increase since 1958 of about 5 percent per year.

16. The number of otters recorded during aerial and limited surface surveys in Alaska was 17,964 and the total population in Alaska waters in 1965 is estimated to be about 25,000.

17. The most recently published Soviet total estimate of sea otters in Soviet waters is 5,300.

18. On the basis of all data available, the world population of sea otters in 1965 was computed to be 32,909. A general estimate of the world population, presuming that some populated areas have not been observed, is about 32,000 to 35,000 animals.

19. Measurements of available sea otter habitat, much of which was not occupied in 1965, and the observed population density of relatively stable populations (10 to 15 otters per square mile of habitat) indicate that the Aleutian Islands and closely related areas of the Alaska Peninsula may eventually support a population of about 50,000 to 74,000 sea otters.

Home Range

The purpose of permanently marking sea otters is to obtain from field observations and recovery of tags, over a period of time, the following information on the life history of individual animals: (1) Maturation, (2) aging, (3) longevity, (4) reproduction, and (5) movements and home range.

Sea otters were captured on shore with a sport fisherman's landing net (fig. 82). While the netted otter struggled to free itself, using forepaws and teeth on the net, one rear flipper was grasped and a cattle or sheep ear tag of monel metal (table 39) was clamped to the web of the hind flipper with a special pliers. Two men were required, one to hold the net and the other to affix the tag. Colored plastic strips were attached experimentally to some tags, so that individual animals might be recognized in the wild.

IGURE 82.—John Nevzoroff holds an adult female sea otter which he captured while it slept on an Amchitka beach. After capture, at least two men are required either to tag an otter or to place it in a carrying cage. (KWK 62-15-20)

All animals that could be captured were tagged, but when a hoice was possible juveniles were captured in preference to dults. When studies were begun, an effort was made to capture others having with them very young pups. This practice, however, was soon discontinued.

Tags were recovered (1) when marked animals were recaptured, 2) from animals found dead on beaches, and (3) during harvestg operations.

Tags were placed on the hind flippers of 224 sea otters (table 9), 107 adults and 117 juveniles or pups. Among them were 88 ales, 135 females, and 1 of unknown sex.

In 1956, 1959, 1961, 1962, and 1963, a total of 28 recoveries ere recorded (table 40). The intervals between tagging and ecovery ranged from 10 minutes to 35 months. Thirteen tagged nimals were recovered dead on beaches, eight were captured and eleased, five were shot, a colored plastic marking device from

TABLE 39.—*Sea otters tagged at Amchitka Island, Alaska*

Year	Tag numbers	Juvenile			Adult		Total
		♂	♀	?	♂	♀	
1956	EL 401–409 [1]	1	1	—	4	3	9
1957	EL 12908 and 12910 [2]	1	—	—	1	—	2
1959	12901–12903; 12926–13000; [3] EL 426, 427, 429–431, 433, 440–442, and 444.	25	21	—	9	31	86
1962	EL 446–565	27	34	—	16	43	120
1963	EL 566–572	4	2	1	—	—	7
Total		58	58	1	30	77	224

[1] This series sheep-ear size.

[2] This series cattle-ear size. The high numbers (12,000 to 13,000) are the result of using tag remainders from Pribilof fur seal series. The prefix EL was hand stamped on only a few. The tags were obtained from the National Band and Tag Company, Newport, Ky.

[3] Except two ruined.

one animal was recovered at a hauling-out place, and one color-marked individual was observed repeatedly.

Two hundred and eight of the animals were captured and tagged at nine traditional hauling-out areas; the remaining 16 were marked at scattered locations on Amchitka Island. Three hauling-out areas are on the Bering Sea coast, five are on the Pacific coast, and one is at East Cape where the Bering Sea and Pacific coasts meet. The minimum distance between the hauling grounds used as tagging locations is 1 mile and the maximum distance is 9 miles. Eight animals tagged at one hauling-out place were subsequently recaptured at the next nearest one.

Three females, tagged as adults and recovered nearly 3 years later, were found 2.5, 2.5, and 5 miles, respectively, from the locations of tagging. One female recovered 2 years after tagging was ½ mile from the location of tagging. Two females recovered about 1 year after tagging were 2.5 and 2 miles from the location of tagging and two others were recovered at the location of tagging.

One young adult male, whose tag bore a colored plastic flag, was observed repeatedly. This animal visited the location where we discarded fish remains in Constantine Harbor, near Kirilof Dock. He was present daily for a period of about a month and a half. He became tame and was captured by hand when he came ashore to accept food. Because of the artificial food source, the sedentary behavior of this animal may not represent the normal behavior of the adult male. One juvenile male, tagged at East Cape, was found dead 24 days later in Constantine Harbor, 9 miles from the location of marking. Among five juvenile males, recovered within a month of tagging, however, only one was as far as 3 miles from the tagging location.

TABLE 40.—*Recoveries of tagged sea otters at Amchitka Island*

Tag number	Date[1]		Period free[2]	Location[3]		Distance moved[4]	Sex	Age[5]		How observed[6]
	Tagged	Recovered		Tagged	Recovered			Tagged	Recovered	
EL 401	21-5-56	23-5-56	3 da	CH	CH	¼ mi	♀	J	J	BD
EL 402	26-5-56	31-5-56	6 da	SMP	RRP	3 mi	♀	A	A	PS
EL12910	28-11-57	11-12-57	1 mo+	CH	CH	O	♂	A	A	O[7]
EL12951	2-3-59	26-3-59	24 da	EC	CH	9 mi	♂	J	J	BD
EL12903	1-4-59	2-4-59	24 hr	RRP	RRP	100 me	♀	A	A	O
EL12902	2-4-59	21-4-59	19 da	SMB	SMB	½ mi	♂	J	J	CR
EL12972	2-4-59	4-4-59	2 da	SMB	SMB	½ mi	♀	J	J	BD
EL12975	2-4-59	14-4-59	12 da	RRP	RRP	O	♀	J	J	CR
EL12941	5-4-59	13-2-62	34 mo	CP	KB	5 mi	♀	A	A	S
EL12945	7-4-59	15-4-59	8 da	RRP	RRP	¼ mi	♂	J	J	BD
EL12948	8-4-59	18-3-62	35 mo	SMP	AB	2.5 mi	♀	A	A	BD
EL12993	15-4-59	10-2-62	34 mo	RRP	SMB	2.5 mi	♀	A	A	S
EL12995	15-4-59	18-5-61	25 mo	RRP	RRP	0.5 mi	♀	A	A	BD
EL13000	18-4-59	8-5-59	20 da	SMP	SMP	O	♂	J	J	C
EL 456	15-2-62	18-2-62	3 da	RRP	SMB	3 mi	♂	P	P	CR
EL 455	15-2-62	19-3-62	1 mo	RRP	B	5 mi	♀	A	A	BD
EL 457	15-2-62	16-2-62	1 da	RRP	RRP	1 mi	♀	J	J	CR
EL 457	15-2-62	26-2-62	11 da	RRP	RRP	O	♀	J	J	BD
EL 464	16-2-62	27-3-62	39 da	RRP	RRP	1 mi	♀	J	J	BD
EL 490	26-2-62	19-3-62	21 da	RRP	RRP	0.4 mi	♀	J	J	BD
EL 497	27-2-62	31-3-63	13 mo	SMP	AB	2 mi	♀	A	A	S
EL 499	27-2-62	5-3-62	6 da	RRP	SMB	2.5 mi	♂	J	J	BD
EL 502	1-3-62	20-3-63	13 mo	AB	AB	O	♀	A	A	BD
EL 513	3-3-62	27-3-63	13 mo	AB	AB	O	♀	A	A	S
EL 525	7-3-62	7-3-62	10 mi	SMP	SMP	100 me	♀	A	A	CR
EL 529	7-3-62	8-3-62	1 da	SMP	SMP	O	♀	J	J	BD
EL 526	7-3-62	8-3-62	1 da	SMP	SMP	O	♀	A	A	CR
EL 556	22-3-62	18-3-63	12 mo	RRP	SMP	2.5 mi	♀	J	SA	S
EL 570	25-3-63	29-3-63	4 da	CRP	CRP	O	♀	J	J	BD

[1] Day, month, and year.

[2] Period free, mi = minutes, hr = hours, da = days, mo = months.

[3] Location abbreviations: AB = Aleut Beach (not to be confused with Aleut Point), B = beach, not named, CH = Constantine Harbor, CP = Constantine Point, CRP = Crown Reefer Point, EC = East Cape, RRP = Rifle Range Point, SMB = St. Makarius Bay, SMP = St. Makarius Point.

[4] Distance moved: O = same location, me = meters, mi = miles.

[5] Age at tagging and at recovery, P = pup, J = juvenile, SA = subadult, A = adult.

[6] How observed: BD = beach dead, O = observed, PS = plastic strip found on hauling ground, S = shot, CR = captured and released.

[7] From about mid-October this animal remained near Kirilof Dock. It was given fish heads and became tame. It was easily captured when it came ashore for fish heads on 28 November and was tagged. It was last seen when we left on 11 December.

The tagging of newborn or very young pups was discontinued because the frightened mother, upon release, usually made several long dives. It seemed probable that at least some of these young pups may have died as a result of unusually long periods of immersion. Also, several mothers refused to accept their helpless pups when they were released and later failed to return for them.

DISCUSSION

To date the information from tagging is meager. Many of the animals which were captured on land were there because they were ill or in weakened condition. For this reason, the rate of survival of tagged animals is probably lower than for the population as a whole. There is as yet no reason to believe, however, that the act of tagging increased the mortality within the tagged segment of the population as compared to the untagged segment (except when mothers with small pups were captured). Disturbance of the animals during tagging was brief and care was taken not to injure them. The tag placed in the web of the hind flipper had no noticeable effect on swimming. Marked animals, in the wild and in captivity, ignored their tags, except that certain individuals chewed the colored plastic flags attached to the metal tag.

The data and general field observations lead to the following tentative conclusions: (1) The home range of the female sea otter during at least a 3-year period may include about 5 to 10 miles of coastline. Soviet biologists found that the range from the "basic station is 15 to 17 km. [9.3 to 10.5 miles]" (Nikolaev and Skalkin, 1963). (2) Animals tagged on one side of Amchitka did not move around to the other side of the island (see Distribution and Numbers). (3) Males may have a larger home range than females. (4) Individual otters may use more than one of the traditional hauling-out places.

Additional information from tagged animals is found in sections on "Age at Sexual Maturity," "Age Specific Mortality," and "Juvenile Sex Ratio."

Territoriality

It is difficult to say whether territorialism exists in the sea otter in the same sense that it does in other mammals. Many sea otters, both male and female, share much of the same home range within which the two sexes mingle to some degree. Also they may segregate to haul out in traditionally established locations (see Segregation of Sexes).

I repeatedly saw lone adult male otters in the same locations ear the shore of Kirilof Point, a female area. During a period of weeks, one of these slept daily on the same rock. Another abitually rested in a kelp bed or on rocks on the shore of a eltered cove. Although I saw transient males in the same general cinity, I did not observe any behavior that might be interpreted territorial defense.

When a female, searching for food or moving along the coast, ssed the area occupied by a sedentary male he swam to her and tempted courtship. If the female was not receptive and passed , the male returned to a favorite feeding or resting place. If e female was receptive, she chose a rock in the vicinity where e pair slept and groomed during the mated period (see Breeding ehavior) of up to several days.

Thus, males seeking an estrous female may be sedentary and ait for one in some favorite "territory," from which other males e not driven, or may actively search for estrous females. The aximum time that a male may remain in a limited location or main away from one of the male haul-out areas was not asrtained. It is my conclusion that territoriality is but weakly pressed in the sea otter.

REPRODUCTION

Sex Ratio

Because sea otters segregate themselves according to sex, the raw data from samples killed, captured, or found dead on beaches at Amchitka Island must be carefully evaluated before drawing any conclusions concerning the sex ratio among different age classes.

PRENATAL SEX RATIO

Three samples of fetal sea otters are available from females killed in 1962 and 1963. The data are summarized in table 41. The smallest fetus in which sex was positively determined weighed 8.80 g. Among the 58 fetuses in which sex was determined, the ratio was 45 percent males: 55 percent females. The fact that the two 1963 samples show a nearly 50:50 ratio indicates that until a larger sample is available the prenatal sex ratio may, for practical purposes, be considered to be about 1:1.

JUVENILE SEX RATIO

Data on the sex ratio of juvenile otters were gathered during tagging studies when sea otters were netted, tagged, and released. This work was done mostly before the period in which high mortality occurred. The young otters were in the areas frequented primarily by females with young. Many of the young that were captured for marking were still in company of their mothers or recently separated from them. Mortality among young in company with their mothers is not known but apparently is low or moderate.

TABLE 41.—*Prenatal sex ratio at Amchitka Island*

Date taken	Number			Ratio (percent)	
	Males	Females	Total	Males	Females
22 Jan.–9 Mar. 1962	4	9	13	31	69
17–31 Mar. 1963	18	19	37	49	51
31 July–3 Aug. 1963	4	4	8	50	50
Total	26	32	58	45	55

Little geographical segregation of deserted juveniles had aparently occurred at the time tagging was done. Therefore, this lass of animals contributes the best indication of sex ratio among ea otters up to approximately 1 year of age. Among 117 juveniles hat were captured and marked, 58 males, 58 females, and 1 of nknown sex were recorded (table 39, section on Home Range). This evidence suggests that the sex ratio is approximately 1:1 durng the juvenile period.

ADULT SEX RATIO

The areas in which females predominated were the most accessile to hunters. Also, these areas are more extensive than the ocations frequented by males (see Segergation of Sexes). Primaily for these reasons the sex ratio of animals taken during ropping operations in 1962 and 1963 were biased in favor of emales. The take consisted of 67 percent females and 33 percent males (table 42). In the section on mortality it was shown that he sex ratio among juveniles found dead on beaches during the ate-winter to early-spring period of stress was 58 percent males: 2 percent females. These data suggest that among surviving dults, females outnumber males. The percent by which females redominate among adults, however, cannot be derived from the vailable data. The difference between the number of males and emales taken during killing operations is a result of sexual segreation and is too great to be explained by the apparent difference n male and female mortality among juveniles.

Until further studies are conducted, it may be concluded that nearly equal number of males and females are conceived and hat the sex ratio remains approximately 1:1 until juveniles are eserted by their mothers. At this time, more males than females ie of natural causes. Thus, among adults, females probably preominate over males. Harvesting operations tend to confirm this ut more data are needed.

ABLE 42.—*Sex ratio of sea otters killed at Amchitka Island during experimental harvests*

[Ratio, males to females, 1:2]

Date	Males		Females		Total number
	Number	Percent	Number	Percent	
an.-Mar. 1962	43	28	111	72	154
ct. 1962	6	25	18	75	24
ar.-Apr. 1963	109	36	194	64	303
Total	158	33	323	67	481

Segregation of Sexes

Male and female sea otters at Amchitka habitually segregate themselves and, almost always occupy distinct geographical areas at all seasons. This condition first became apparent during observations when otters in various areas were counted and the numbers of each sex recorded. Additional information was obtained when otters were captured on beaches and when those dying of natural causes were recovered. During harvesting operations in 1962 and 1963, more quantitative data on the degree of segregation became available (tables 43 and 44). The terms "male area" and "female area" refer to the geographical locations used predominantly (but not exclusively) by each sex. Marakov (1965, p. 213) noted sexual segregation among otters at Medny Island, Commander Islands, U.S.S.R.

FEMALE AREAS

These are more numerous and less discrete than male areas (fig. 83, map). Seven female areas are listed in table 43. At these places the adult females usually haul out in favored sheltered places near the extremities of points. In general, they appear less bound to a limited hauling out location than the males. Certain locations, however, such as St. Makarius Point W., Rifle Range Point, and Constantine Point, are more favored than others. Tag recoveries reveal that females may use more than one of the favorite hauling grounds (see Home Range). The kill of adult females reveals that they are generally distributed along the coast when feeding. Many were taken a kilometer or more from favored haul-out locations. Observations as well as data from the kill indicate that females not only avoid the male haul-out locations but also avoid the feeding habitat adjacent to them. Among 242 adult otters killed in female areas, 93 percent were females. When 20 animals, not accompanied by a pup but in female areas, were killed selectively (31 July to 3 August 1963) in an effort to take males, only one male was obtained. This sample may indicate that males constitute only 5 percent of the animals in female areas.

MALE AREAS

Three locations on the eastern half of Amchitka (fig. 83, map) are used almost exclusively by males; the southeast tip of St. Makarius Point (SMPE) about 800 m. of beach, the north beach and tip of East Cape (ECN) about 500 m. of beach, and Crown Reefer Point (CRP) about 600 m. of beach. Along each of these

[All otters were shot during harvesting operations in 1962 and 1963. The only selection of animals shot was that adults were taken in preference to juveniles when both were present]

Location [1]	Adults					Juveniles					Adults and juveniles				
	Males		Females		Total number	Males		Females		Total number	Males		Females		Total number
	Number	Percent	Number	Percent		Number	Percent	Number	Percent		Number	Percent	Number	Percent	
RRP	0	0	20	100	20	4	50	4	50	8	4	14	24	86	28
SMB	1	9	10	91	11	2	18	9	82	11	3	4	19	96	22
SMPW	7	12	51	88	58	8	62	5	38	13	15	21	56	79	71
CP-IP	1	1	70	99	71	5	31	11	69	16	6	7	81	93	87
CH-KB	7	12	49	88	56	12	34	23	66	35	19	21	72	79	91
AMB	1	9	10	91	11	0	0	1	100	1	1	8	11	92	12
ECS	1	7	14	93	15	0	0	0	0	0	1	7	14	93	15
Total	18	7	224	93	242	31	37	53	63	84	49	15	277	85	[2] 326

[1] RRP = Rifle Range Pt.; SMB = St. Makarius Bay; SMPW = St. Makarius Pt. West; CP-IP = Constantine Pt. to Ivakin Pt.; CH-KB = Constantine Harbor to Kirilof Bay; AMB = Aleut Midden Beach; ECS = East Cape South.

[2] Of the 326 animals taken, 84 (25.8 percent) were juveniles.

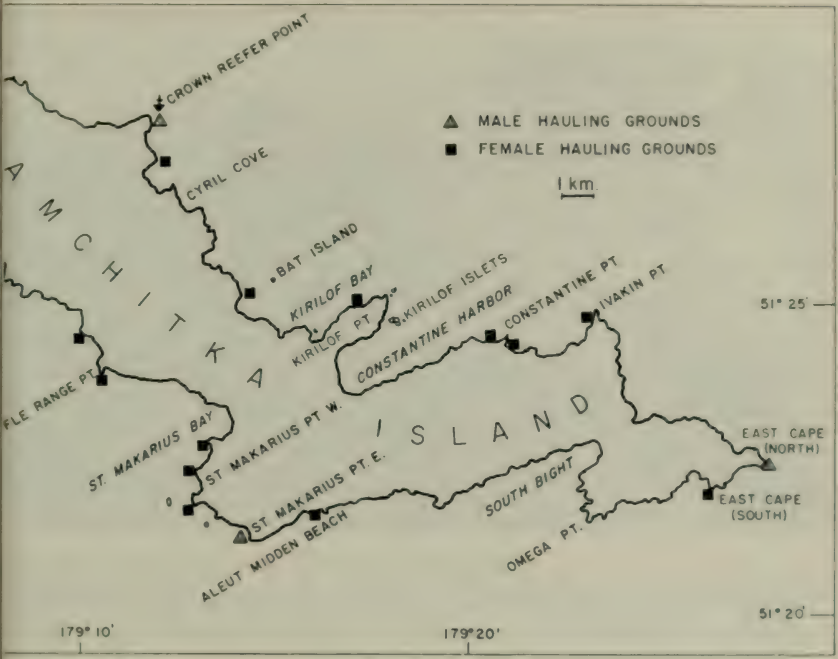
TABLE 44.—*Sex and age of sea otters taken in three areas frequented mostly by males at Amchitka Island*

[With the exception of the otters taken at CRP, otters were shot in 1962 and 1963 during harvesting operations. There was no selection of animals shot except that adults were taken in preference to juveniles. Because of its remoteness, otters were not harvested at CRP. The animals listed from there were found dead on beaches in 1956, 1959, 1962, and 1963. Remains showing no positive evidence of sex are omitted]

Location [1]	Adults					Juveniles					Adults and juveniles				
	Males		Females		Total number	Males		Females		Total number	Females		Males		Total number
	Number	Percent	Number	Percent		Number	Percent	Number	Percent		Number	Percent	Number	Percent	
SMPE	37	97	1	3	38	14	78	4	22	18	51	91	5	9	56
ECN	46	98	1	2	47	7	78	2	22	9	53	95	3	5	56
CRP	17	100	0	0	17	7	88	1	12	8	24	96	1	4	25
Total	100	98	2	2	102	28	80	7	20	35	128	93	9	7	[2] 137

[1] SMPE = St. Makarius Pt. East; ECN = East Cape North; CRP = Crown Reefer Pt.

[2] Of the 137 animals taken, 35 (25.5 percent) were juveniles.



IGURE 83.—The southeastern end of Amchitka Island showing the most favored male and female hauling grounds. Individual animals may haul out at almost any location along the shore. At the locations indicated on the map, however, aggregations of sea otters are habitually formed when numbers of animals come ashore to rest at all seasons.

aches the majority of animals habitually haul out on 40 to 50
. of beach. A few individuals may haul out indiscriminately at
rious distances from the most favored location. When a number
otters are hauled out, they usually congregate in groups, often
eeping in contact with one another (fig. 84). Among 102 adult
ters killed in these areas, only 2 were females (table 44).

It appears that the males, except those actively seeking to mate,
mit feeding activities to a radius of several hundred meters from
e haul-out location. If they did not do this, more than 7 percent
ales (table 43) would have been shot in the female areas during
lling operations. When mating activity was observed (see Breed-
g Behavior), males actively sought estrus females and mating
as observed only in female areas. Thus, it is reasonable that a
gher proportion of males was found in the female areas than
males in male areas.

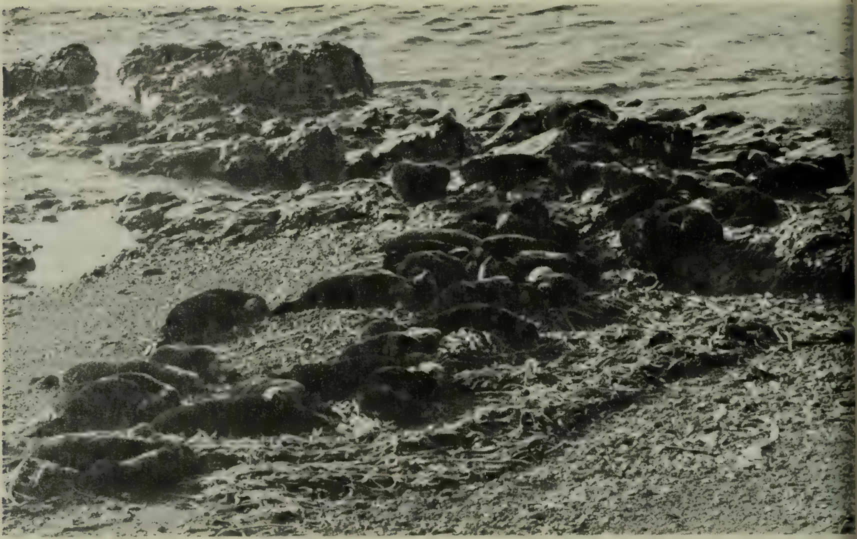


FIGURE 84.—A group of 39 otters sleeping at St. Makarius Point East, Amchitka Island, a favorite hauling ground for males. The many sleeping positions are demonstrated. Some lie on their backs, others on the belly or side, or curled nose-to-tail. (KWK 65–27–34)

JUVENILES

The foregoing paragraphs dealt primarily with adults. Segregation of sexes is more pronounced among adults and subadults than among independent or newly weaned juveniles. Among 35 juveniles taken in male areas, 80 percent were males (table 44). In female areas, among 84 juveniles examined 63 percent were females (table 43).

Since juveniles are or were recently associated with their mothers, it might be expected that a larger number would be found in the female areas than in the male areas. The percent of juveniles taken in both male and female areas was, however, the same, about 26 percent (see footnotes, tables 43 and 44). This may indicate that independent juveniles wander to all areas and mingle with any group of adults. It also appeared, however, that juveniles were more attracted to areas occupied predominantly by adults of their own sex (20 percent female juveniles on the male areas and 37 percent male juveniles on female areas). Perhaps because of the recent mother-young relationship the proportion of young males on the female area was greater than the proportion of young females in the male areas.

iscussion

The largest aggregations (animals hauled out in close proxnity on the same rocks) were seen on male hauling grounds at mchitka. I saw from 70 to over 100 on several occasions at ast Cape. I seldom saw more than 10 to 15 females in close roximity on the same rock at any hauling ground (fig. 85). uring aerial surveys, certain large aggregations contained few, any, mothers with small young as far as we could ascertain.

Large aggregations were photographed at sea off Unimak land (fig. 81) and mothers carrying small pups were not detected n the photograph. In the same general area but away from the ggregations, however, I saw many mothers carrying young on eir chests. These mothers with young were usually alone but casionally two were near each other. It thus appears that males nd females habitually segregate themselves, both when on the uling grounds and in offshore locations.

More observations of this aspect of social behavior are needed

GURE 85.—Rifle Range Point, a female hauling ground. Three of the females have entered the water; eleven adults and large juveniles remain on the rocks. (KWK 62-17-31)

in other island populations. Knowledge of the degree of segregation of sexes and the locations of areas where males concentrate may prove useful in management operations.

As mentioned elsewhere (Breeding Behavior), males often patrolled female feeding areas and attempted courtship with all females present. In the course of 3 or 4 hours, two to four males might pass separately through such an area.

Breeding Behavior

Observations at Amchitka are often hindered by dense fog. This fact and the tendency of mated pairs of otters to occupy offshore rocks, have prevented me from following any one pair of otters through all phases of the breeding cycle. I have, however, recorded observations of 41 mated pairs in the wild. Among these, copulation was initiated by 13 males which were not successful in completing it. Copulation was completed, apparently successfully, in eight cases. The remaining 20 observations were of paired animals in close company which, as explained later, exhibited the behavior typical of mated pairs. Excluded from the records are observations of unsuccessful attempts at courtship by males toward unreceptive females. The data on various aspects of the breeding cycle were obtained from many pairs observed briefly and from the observation of one pair which remained for about 3½ days in a sheltered cove (table 45). These observations indicate that the cycle of breeding behavior is rather uniform. A description of behavior during the different phases of the breeding cycle follows:

COURTSHIP OR PRECOPULATORY PERIOD

As mentioned elsewhere, adult males and adult females segregate themselves to a considerable degree. When a male seeks a

TABLE 45.—*Activities of a mated pair of sea otters during observations on 19, 20, and 21 August 1955*

19 August, 1634-1810. The male and female remained in close company at all times.

Activity	Number of periods	Elapsed time (minutes)		Total minutes	Percent of time
		On land	In water		
Copulation	2	—	35	35	37
Grooming	2	39	2	41	43
Sleeping	1	19	—	19	20
Total	5	58	37	95	100

BLE 45.—*Activities of a mated pair of sea otters during observations on 19, 20, and 21 August 1955—Continued*

August, 1542-1910. The male left the female resting on the rock when he ntinued food diving, but he remained close to her while she was in the ter.

ctivity	Number of periods	Elapsed time (minutes) On land	Elapsed time (minutes) In water	Total minutes	Percent of time
le:					
Feeding	4	—	79	79	38
Groom and wash	4	1	23	24	12
Sleep and rest	2	52	40	92	44
Sexual behavior (play)	5	4	8	12	6
Investigate strange female	1	—	1	1	>1
Total	16	57	151	208	100
nale:					
Feeding	2	—	58	58	28
Groom and wash	1	21	—	21	10
Sleep and rest	3	108	9	117	56
Sexual behavior (play)	2	4	8	12	6
Total	8	133	75	208	100

August, 1052–1820. The male left the female resting on the rock when he tinued food diving, but he remained close to her while she was in the water.

ctivity	Number of periods	Elapsed time (minutes) On land	Elapsed time (minutes) In water	Total minutes	Percent of time
e:					
Feeding	10	—	310	310	70
Groom and wash	5	—	40	40	9
Sleep and rest	2	—	72	72	16
Sexual behavior (play)	5	5	20	25	5
Sniff rock	1	1	—	1	>1
Total	23	6	442	448	100
ale:					
Feeding	7	—	247	247	55
Groom and wash	6	9	41	50	11
Sleep and rest	8	61	65	126	28
Sexual behavior (play)	5	5	20	25	6
Total	26	75	373	448	100

22 August a dense fog prevented detailed observations.

mmary of activities of mated pair of otters on 19, 20, and 21 August 1955, ring three observation periods totaling 749 minutes (12 hours, 29 minutes).

tivity	Total elapsed time: Male Minutes	Total elapsed time: Male Percent	Total elapsed time: Female Minutes	Total elapsed time: Female Percent
ding	389	52	305	41
om and wash	103	14	110	14
p and rest	183	24	262	35
ual play	72	10	72	10
f rock	1	>1	—	—
stigate strange female	1	>1	—	—

female in estrus, he usually swims belly down and rapidly on the surface (fig. 86) and seldom dives for food. He closely skirts favorite hauling-out rocks, and he may rise high in the water to look onto the rocks, or leave the water to walk quickly about, sniffing the rocks. If he sees a feeding female floating on her back he swims directly to her. He may come up beneath her and attempt to put his forelegs around her chest from behind, his forepaws resting in or near her axillae. Or he may rise up beside her. He may rub and pat her chest, belly, and genital area with his forepaws, or he may nuzzle and appear to sniff them with his nose. If the female is unreceptive, she rolls away from him and pushes him away with her flippers and paws, or snaps at him. Before departing he may snatch whatever food items she has on her chest.

If she is receptive, the two may roll and frolic together. During

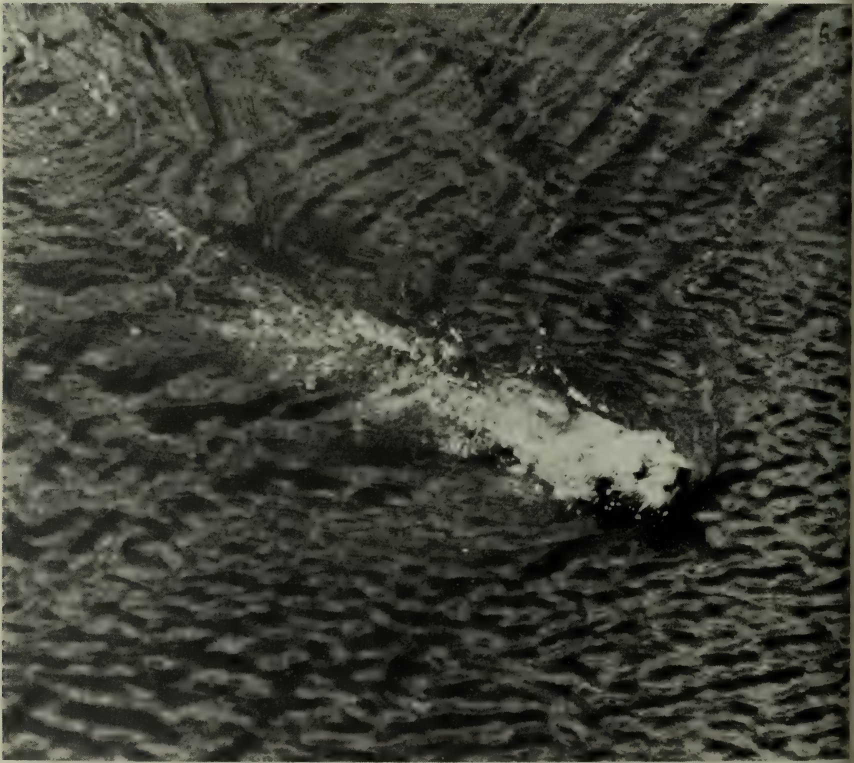


FIGURE 86.—Adult males actively searching for estrous females in areas habitually frequented by feeding females often swim belly down rather than in the more usual inverted position. (KWK 1026)

is period, the male may grasp the female about the chest from ehind with his forepaws and attempt to grasp the side or back of er head or her nose in his jaws. At this rather rough stage of urtship, the female may disengage herself, snap at the male, d push him away with her flippers and paws. The two may now parate, but if the female is not determined in her resistance e male may follow her; or, occasionally, the female may follow e departing male and rough courtship behavior will continue. the female is in estrus, she becomes increasingly submissive as urtship continues.

After the male has found an estrous female, the two continue tively to roll and splash about on the surface together. They uzzle each other and fondle each other with the forepaws. Similar havior was noted in the polecat by McCann (1955). Such beavior apparently lasts for a variable period, perhaps up to an ur. In the course of their activities the animals usually make eir way, with the female leading, toward a suitable hauling-out ck which the female selects. This spot becomes the center of eir activities during the mating period.

OPULATORY PERIOD

Copulation takes place in the water near the hauling-out rock. hen the female is ready for coitus, her body becomes rigid and e lies belly up on the surface, her back somewhat bowed (i.e., ncave) and her forelegs rigid and protruding vertically in front her. The male grasps the female's upper jaw usually, including r nose, in his jaws, or he may grasp the side of her head. If the ated pair are on land during precoital play, the male leads the male into the water after grasping the side of her head in his ws. He clasps her tightly from the back ("more canum"), his ws resting against her chest in or near her axillae. At the same me the already extruded penis is inserted as the male rests ainst the female's back, slightly on one side of the mid-dorsal ea. The rear feet of the male are in motion, so that the two imals move about in a wide circle and roll from side to side. riodically they lift their noses above the surface. For the most rt, the male is beneath the surface and the belly and chest of e female are above it. The female frequently emits loud shrieks d gurgling gasps which indicate that she experiences difficulty breathing.

In one case (19 August 1955), after copulation had continued r 14 minutes, the female struggled and wrenched her body, sengaging the male's penis. The male, however, retained his grip on the female's head with his jaws, and the two animals, linked together by their heads, spun rapidly over and over in the longitudinal axis on the surface. The spinning continued for only a few seconds. Then the female became limp, the male again aligned his body with her back and grasped her with his forelegs, and copulation continued for an additional 9.5 minutes. When the male released his grip after an elapsed time of 23.5 minutes, the female's nose was gashed and bleeding. The two animals immediately began to groom and scrub their fur. Then, the female leading, the pair swam to and hauled out on the rock where they had previously engaged in courtship. Here they continued to groom and dry their fur for 10 minutes. The female was particularly vigorous in this activity. During this period and subsequent periods of association with the male on the chosen rock, the female almost constantly uttered a soft chuckling sound. After drying their fur, the pair went to sleep curled up close beside each other. The time was late afternoon and presumably, as was observed on other occasions, they slept in this location until after sunrise the next day.

While most observations indicated that the male initiated mating activities, estrous females were observed to tease or stimulate a reluctant male. In one instance (7 May 1956 at 1715 local time) I saw a male and female sleeping close beside each other in a kelp patch. They appeared to be a mated pair, and I presumed that copulation had occurred. While I watched, the female awoke and began to nuzzle the male about the head and abdomen. The male was slowly aroused from sleep and at first appeared indifferent to the attention of the female. Within about 30 seconds, however, he clasped her with his forepaws, then grasped the side of her head in his jaws. The female then became rigid (as described elsewhere) and copulation was accomplished. Unfortunately, after copulation had continued for 11 minutes, their motions carried them behind rocks, and it was not possible to obtain further observations of the pair.

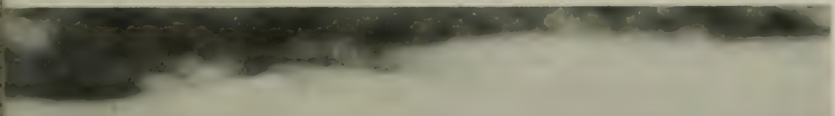
In one case, a second copulation occurred about one-half hour after the first. Various observations of behavior indicate that more than one copulation may be usual.

Copulation usually occurs in the afternoon. I have 21 observations of copulation and attempted copulation during the afternoon, but only 1 recorded for morning (1030).

Barabash-Nikiforov (1947) says that during coitus the pair "cling to each other, intertwining belly to belly, and revolve around the longitudinal axis." Murie (1940) also said "position parently being with the ventral surfaces opposed, although of is I could not be positive." In all nine cases of completed copu-tion that I observed, the male clasped the female from behind d remained dorsal to her but slightly to one side of her median rsal line during copulation. Because of the position of the female, ing rigidly on her back with forepaws extended, immediately be-re coitus, it would seem unusual that the position of the male ould be other than dorsal to her body during copulation.

OSTCOPULATORY PERIOD

In one case this period was observed to last for 3 days (19 rough 22 August 1955, table 45). The pair fed, groomed, and sted in close company (fig. 87). Occasionally they engaged in ort periods of play, and the male sometimes attempted copu-tion. The female, however, appeared to be unreceptive during is period. The pair rested periodically on the chosen hauling-out te and slept beside each other during the night.



GURE 87.—A pair of sea otters (female on left) rest and groom beside each other shortly after mating. The light colored head is more typical of males than females. As shown here, females tend to be more alert and watchful than males. Males tend to be phlegmatic and take alarm less easily than females. The nose of the female was grasped in the teeth of the male during mating and is swollen. The broader and heavier head and neck of the male is evident. (KWK 975)

The male followed the female closely, often being in contact with her while the two consumed food, side-by-side on the surface. When the female dived for food the male quickly followed, often discarding a food item that he had not finished eating. When the female surfaced, the male emerged a fraction of a second behind her.

During this period the male left the female's side only after the two had emerged and groomed following a feeding period. While the female remained on the chosen rock to groom and sleep, the male dived for food nearby. While eating he swam back near the chosen hauling-out rock to eat, and often glanced at the female before diving.

On the third day of the mating period the male exhibited less interest than previously toward his mate, and several times stole food from her. Also, he followed her in food dives less promptly. The pair had left the cove by shortly after daylight on the morning of 23 August.

THE SEPARATION PERIOD

The breaking of the pair bond was observed on several occasions. The female, in each case, deserted the male. Probably because the male is larger than the female he requires more food, and as a general rule he returns to the water to continue feeding while the female rests on land. In one instance, the food dives of the male gradually carried him about 50 m. from the female's resting place. She watched him intently and, suddenly, while the male was beneath the surface gathering food, she slipped quietly into the water and swam rapidly away beneath the surface. Apparently the visual acuity of the male was inadequate to detect immediately from his feeding station the absence of the female. When the male returned for one of his periodic visits to his mate on the chosen rock and found her gone, he left the water and walked rapidly about, sniffed the spot where the female had rested, and looked quickly at possible hiding places nearby. Apparently satisfied that the female was gone, he entered the water and swam hurriedly to several nearby hauling-out places, rising high in the water to look onto them. He also rose high in the water to look across the surface in different directions. Although I observed several such episodes, I never saw a male relocate the female after her departure.

In general, it would appear that during the postcopulatory period the female exhibits less interest in retaining the pair-bond than does the male. The female may, however, exhibit sexual nterest, or even protective behavior, toward the male. What might e interpreted as protective behavior was exhibited by an adult emale of an apparently mated pair that slept close beside each ther on tidal rocks at 1630 on 2 March 1962. The more alert female tarted to leave the rock when she saw me approaching. When he sleeping male failed to awaken and follow her, she returned o him and, after pressing her paws against his face, neck, and hest and crawling on top of him, she finally aroused him. She hen pressed her body against him from behind, inducing him to nter the water and follow her out of the area (figs. 88 and 89).

REEDING BEHAVIOR VS. SOCIAL BEHAVIOR

Barabash-Nikiforov (1947) stated that "A grown cub often emains with the mother even after a new one is born, so that he mother is seen together with the newborn and yearling." This atement implies that a mother accompanied by a pup may articipate in breeding activity. Murie (1940) describes a situation e observed in the Aleutians in which it appeared that the mother f a young pup engaged in coitus while the "little one . . . was cryg at the far edge of the kelp."

I have observed a mother with a pup engage in rough play with courting male during which the male attempted coitus. I have ot, however, seen a female accompanied by a pup complete coitus r participate with the male in the breeding behavior cycle. In all stances that I have observed, the mother, after a period of play ith the male, eventually retrieved her pup and attempted to sengaged herself from the aggressive male. If the pup was rge, the mother appeared to be considerably mauled as the crying, inging pup clasped her about the head and neck from the front nd the male clung to her from the rear, or tried to intrude beveen the mother and pup. My observations lead me to believe that would be difficult for a mother with a pup to engage in the mating cle of several days duration.

That a mother accompanied by a pup might become impregnated a possibility. Further data on the physiology of reproduction in e female must be obtained before a conclusion could be indicated ith some certainty. Available observations indicate to me that is usual for females to enter estrus only when they are not ccompanied by a pup.

Certain habits of the sea otter could lead to confusion during eld observations. First, rough play might be mistaken for copution. It appears that Fisher (1939) may have made this mistake. econd, sea otters, especially juveniles which are separated from

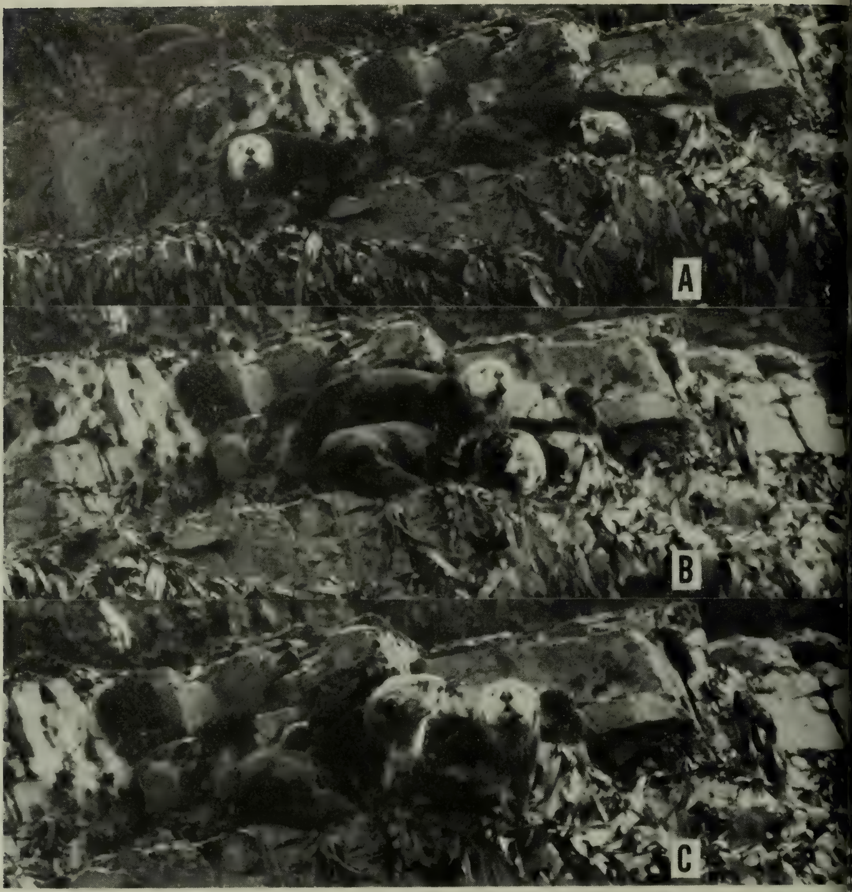
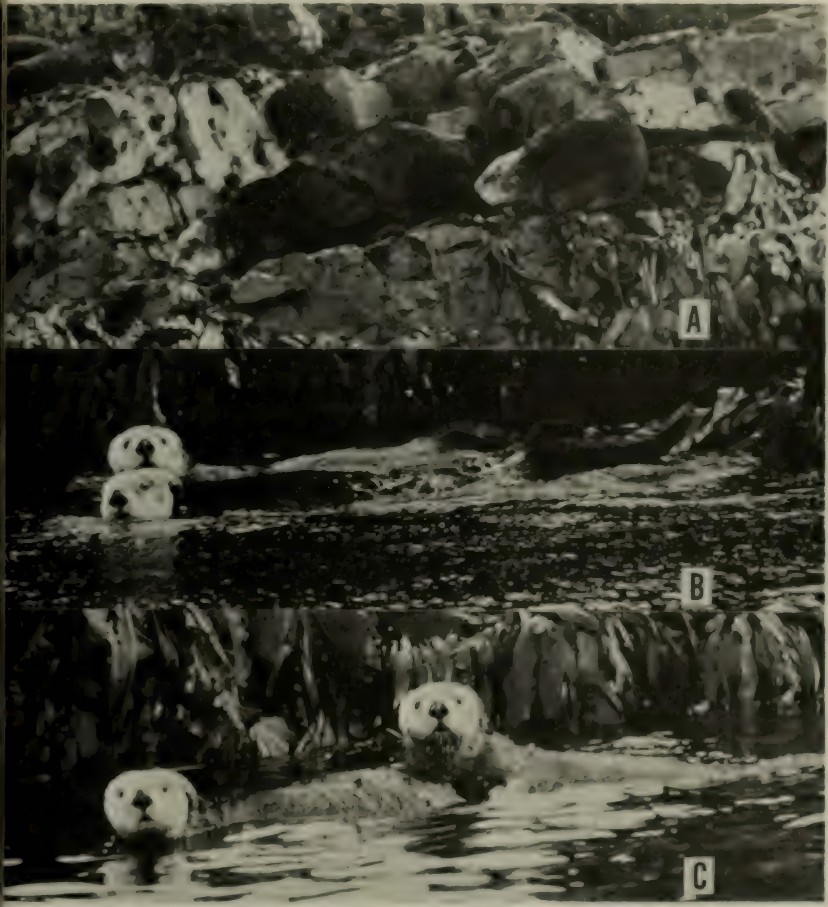


FIGURE 88.—*A*—An adult male and female slept beside each other on a tidal rock (male right, female left). The more alert female was aroused by the click of the camera and started to leave the rock. The male continued to sleep soundly. (KWK 62–19–6) *B*—The female returned and prodded the male with her forepaws and then climbed on top of him, pressing his head and chest with her paws. The male raised his paws to push her away. (KWK 62–19–5) *C*—The male, finally aroused, looked about sleepily while the female stared in alarm at the camera. The female nudged the male toward the water. (KWK 62–19–3)

their mothers, may attach themselves temporarily to an adult either male or female, or to another juvenile. The two animals may play together, and when frightened may cling loosely together with their forepaws.

Figure 90 shows a juvenile which took refuge behind an adult male, beside which it slept. After being disturbed by my presence



GURE 89.—*A*—Finally aroused, the male moved ahead of the female while she prodded him toward the water from behind. (KWK 62-19-1) *B*—As the pair slid into the water the female grasped the still drowsy male and gazed over him at the camera. (KWK 62-19-43) *C*—Finally completely aroused, the male stared in mild alarm while the female clasped his back n her forepaws. Shortly after the last photograph was taken the pair dived and made their way through a narrow channel to open water beyond the tidal rocks. (KWK 62-19-40)

e two swam off together. Since an impregnated female separates om the male shortly after copulation, and family groups include ly the mother and her young, it appears improbable that such association as illustrated would involve family ties.

As a general rule, lone females and females with young are served apart from adult males. But a courting male, after a riod of attempted courtship with a female and her young, may

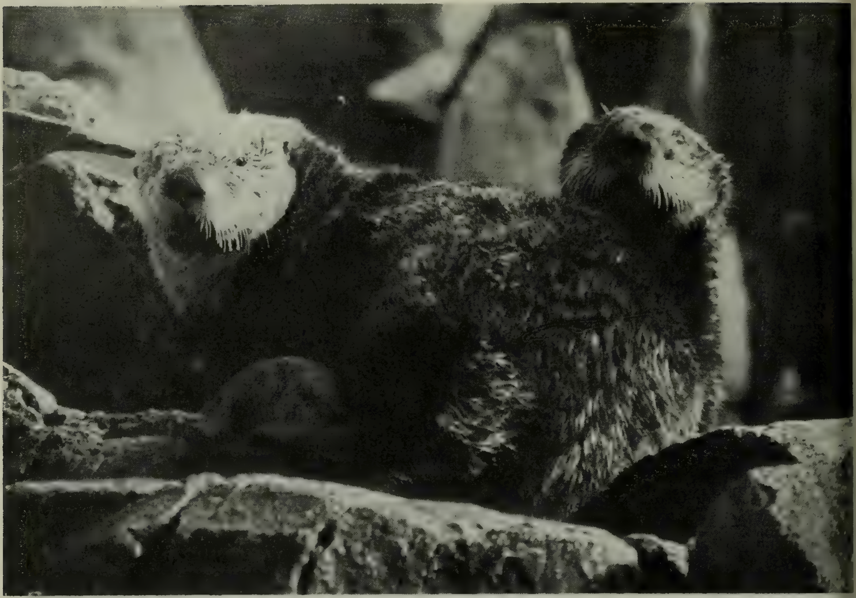


FIGURE 90.—This adult male was tolerant of a deserted juvenile which slept beside him and sought shelter behind him when frightened. When the adult finally became alarmed, entered the water, and swam off, the juvenile remained in close company with him. (KWK 62–25–24)

sleep near them in a kelp bed, or the three may haul out on a rock to groom, rest, and sleep in close association. It would appear that such an association is an expression of gregariousness. On one occasion I watched an adult male and female play roughly together for about 15 minutes. The female was accompanied by a large pup, which during the play period attempted to participate, or swam about nearby and occasionally cried. Although the male tentatively attempted copulation, the female was not receptive. After the three had hauled out and the male had groomed and rested beside the mother and pup for about 20 minutes, he entered the water and left the vicinity. In this case it was apparent that, although the male was sexually motivated, the association of the male and female was casual, and they were not a mated pair. The association described above might lead an observer to form erroneous opinions concerning breeding habits.

Reproduction in the Female

In this section, data from female reproductive tracts, the conceptuses they contained, and field counts of dependent young and dependent animals are combined to present an analysis of re- oduction in the female sea otter. The fundamental histological ıdy on which much of the present analysis of reproductive tracts based was done by Dr. A. A. Sinha under the direction of Dr. C. Conaway (Sinha, Conaway, and Kenyon, 1966). In that study, 6 mature tracts taken from 1954 through 1962 were used. Some ıterial from that collection, which was not published in Sinha al (1966), is included in the present study. It was kindly given me by Dr. Sinha. A study of the histology of the sea otter ovary ıs recently completed (Sinha and Conaway, 1968).

The 1963 collections (table 46) added data from different sea- ns which revealed what the earlier material did not: that there apparently a peak in frequency of births in summer.

Samples representing certain seasons are small. More specimens ɔm summer, fall, and winter are needed before all phases of the productive cycle may be based on an adequately large sample. A ıg-continued field study of marked animals and a captive eeding colony would contribute valuable information on some ases of the reproductive cycle.

My discussion of various aspects of the reproductive material ailable is followed by a statistical analysis of this material by . Douglas G. Chapman.

PRODUCTIVE TRACTS

From 1954 to 1963, reproductive tracts were obtained from imals found dead on beaches, from animals captured (netted) beaches, and from animals shot during experimental cropping ıdies. The adult female tracts that were collected are listed in ɔle 46. The four larger collections from 1962 and 1963 (table 46) ntribute the most useful material. The smaller collections and lividual specimens taken in other years are included where eful in the following analyses. In tables 47 through 51, different

BLE 46.—*Adult female sea otter reproductive tracts from Amchitka Island*

[Except those taken in 1960 These were taken in other areas of Alaska]

eriod	Number	Remarks
-57	14	Taken at various seasons Some from animals found dead Studied by C. H. Conaway and A. A. Sinha
-Apr. 1959	14	Most were netted on beaches, several found dead. Studied by Conaway and Sinha
-July 1960	4	Shot (FWS) Studied by Conaway and Sinha
-Feb. 1962	88	Shot (ADFG) Studied by Conaway and Sinha
1962	14	Shot (ADFG) Studied by Conaway and Sinha.
.-Apr. 1963	125	Shot (ADFG) Studied by Kenyon
-Aug. 1963	19	Shot (ADFG) Studied by Kenyon
Total	278	

TABLE 47.—*Phases of reproduction in the female sea otter as shown by status of ovaries and size of conceptus*

[Information from genital tracts collected from 1954 through 1963 is combined]

	Season of sample collection								
	Jan.–Feb.		Mar.–Apr.		May–Aug.[1]		Sept.–Dec.		Total number
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
Unimplanted blastocyst	35	57	49	50	4	31	6	100	94
Conceptuses:									
Class 1	8	13	9	9	0	0	0	0	17
Class 2	4	7	6	6	0	0	0	0	10
Class 3	4	7	11	11	2	15	0	0	17
Class 4	10	16	17	17	3	23	0	0	30
Class 5	0	0	6	6	4	31	0	0	10
Total conceptuses	26	43	49	50	9	69	0	0	84
Total pregnant	61	70	98	70	13	52	6	27	178
Not pregnant[2]	27	30	42	30	12	48	16	73	97
Total tracts	88	—	140	—	25	—	22	—	275

[1] The 19 adult female sea otters taken between 31 July and 3 August 1963 were killed selectively, mothers accompanied by pups were spared. Thus, the percentage of postpartum nonpregnant specimens in this sample is less than it would have been if the kill had been nonselective.

[2] See table 51 for more details.

TABLE 48.—*Frequency of primiparous and multiparous sea otters*

Period sampled	Total examined	Primiparous		Multiparous	
		Number	Percent	Number	Percent
1963					
15 Mar.–2 Apr.	125	21	17	104	83
31 July–3 Aug.	12	2	17	10	83
Total	137	23		114	

TABLE 49.—*Uterine horn of pregnancy*

Period sampled	Specimens examined	Uterine horn pregnant			
		Right		Left	
		Number	Percent	Number	Percent
Mar.–Apr.	90	46	51	44	49
May–Aug.	7	3	43	4	57
Total	97	49	51	48	49

TABLE 50.—*Weight distribution of embryonic and fetal sea otters*

Weight class	Collected in period[1] —														
	22 Jan. to 13 Feb. 1962[2]					15 Mar. to 2 Apr. 1963					31 July to 3 Aug. 1963				
	Number	Percent	Maximum	Minimum	Mean	Number	Percent	Maximum	Minimum	Mean	Number	Percent	Maximum	Minimum	Mean
No. 1, <1 gram	8	31	0.9	0.5	0.6	[3] 8	16	0.9	0.2	0.2	0	0	—	—	—
No. 2, 1–10 grams	4	15	9.0	7.0	8.0	6	12	8.8	1.1	4.1	0	0	—	—	—
No. 3, 10–100 grams	4	15	80.0	15.0	46.0	11	23	93.0	10.9	39.9	2	25	61.9	36.1	49.0
No. 4, 100–1000 grams	10	39	720.0	140.0	350.0	18	37	882.0	100.5	344.1	2	25	478.0	356.0	417.0
No. 5, 1,000–2,000 grams	0	—	—	—	—	6	12	1,869.0	1,067.0	1,511.2	4	50	1,810.0	1,118.0	1,497.0
Total	26	100				49	100				8	100			

[1] No implanted pregnancies were found in the 1962 fall sample.

[2] Weights from A. A. Sinha (personal communication).

[3] Three of the visibly implanted embryos included here were very small and were not weighed. These are included in the total above but only five that were weighed are represented in the maximum, minimum, and mean weights.

TABLE 51.—*Reproductive status of adult nonpregnant sea otters*

[Nine animals, adult in body size but being nulliparous and showing no follicular activity, are excluded]

Nonpregnant tracts	Samples collected in—						Total
	Spring 1963, Mar.–Apr.		Summer 1963,[1] July–Aug.		Fall, 1957 and 1962, Oct.–Nov.		
	Number	Percent	Number	Percent	Number	Percent	
Postpartum, inactive ovaries:							
Pup present	13	35			8	61	21
Pup absent	16	43	3	60	1	8	20
Inactive ovaries [2]	4	11	2	40	3	23	9
Active ovaries [3]	4	11			1	8	5
Total	37	100	5	100	13	100	55
Total tracts examined and percent not pregnant	125	30	14	36	17	76	156

[1] Animals were killed selectively to exclude all mothers accompanied by young. The objective was to take as many male skins as possible in a female area. Among 19 independent animals, only 1 male was taken.

[2] Multiparous but not showing positive evidence of being recently postpartum.

[3] Estrus and proestrus.

total numbers of specimens are shown because not all specimens could be used for every aspect of this study. I did not examine all collections and samples. Those that I did examine presented adequate information for certain aspects of this study.

The reproductive tracts were removed from the animals from a few minutes to several hours after death, depending on field conditions. They were then fixed entire for 24 hours in AFA solution (95 percent alcohol, 30 percent; commercial formalin, 10 percent; glacial acetic acid, 10 percent; water, 50 percent). After fixing, the tracts were stored for later study in 70 percent isopropyl alcohol.

Sinha et al. (1966) explain how certain aspects of reproductive tract studies were conducted. I examined ovaries with a 10X Loupe after slicing them into sections about 1 mm. in width.

FIELD COUNTS OF SEA OTTERS

Field counts of sea otters were recorded whenever possible. The primary objectives were to obtain information on (1) the season of birth, and (2) the annual rate of reproduction.

Observations were limited by: (1) Environmental conditions such as wind, precipitation, and rough water; (2) a variable degree of sexual segregation among independent animals, including mothers with young; (3) the often indistinguishability of sexes and age classes; and (4) the constant movement of animals to and from local areas. In spite of these factors, useful field observations were obtained.

Counts of otters were made primarily at Amchitka Island, from beaches and cliff tops and during dory trips through inshore waters. Binoculars (7X50) and a telescope (50 power) were used for observation.

DEFINITION OF TERMS

Implanted pregnancy observations are based on visible swellings of the uterine horn, presence of a corpus luteum, and recovery of the conceptus. *Unimplanted pregnancy* observations are based on the presence of a corpus luteum not accompanied by swelling of the uterine horn. Sinha et al. (1966) demonstrated that when a corpus luteum is present and no uterine swelling is visible a blastocyst may be recovered from the uterine horn. *Multiparous* animals were separated from *nulliparous* and *primiparous* animals by the thickened appearance of the uterine horns which, after having held a conceptus, do not regain the smooth, firm texture of the nulliparous uterine horn.

Tracts were classified as *nonpregnant* when no corpus luteum was present. A female was considered to be *post partum* if one or more of the following conditions was observed: (1) lactation, (2) presence of a pup, (3) presence of a corpus albicans, (4) presence of a placental (uterine) scar. Because it appears that the young sea otter remains with its mother for about a year, certain evidence of a post partum condition may be obscure by the time the pup and mother part. The placental scar may virtually disappear and the corpus albicans may be reduced in a female accompanied by a large pup. One lactating female, whose pup was either recently lost or was not seen by the hunters, showed no placental scar and the corpus albicans was very small.

Classification of ovaries as *estrous*, *proestrous*, and *anestrous*, based on macroscopic examination of sectioned ovaries, are considered briefly in the following discussion. The objective of this study is to present a review of the natural history of reproduction.

AGE AT SEXUAL MATURITY

Sufficient data are not available to fix with certainty the age at sexual maturity. Some information was obtained from a juvenile female (approximately 1 year old), weighing about 24 lb. (10. 9 kg.), that was tagged (EL 556, table 39) on 22 March 1962. On 18 March 1963, when this animal was shot 2.5 miles from the place of marking it weighed 33 lb. The dentition was that of a young adult, but the reproductive tract was decidedly immature.

It can thus be said that the female sea otter does not mature sexually until after 2 years of age.

The mean weight of 39 pregnant females was 50 lb. (22.7 kg.) (extremes 36 and 70 lb.). Among 21 primiparous females, the mean weight was 43 lb. (19.5 kg.) (extremes 35 and 52 lb.). If the marked 33-lb., 2-year-old had continued to grow during her third year at the rate she did in her second, her weight would have approximated the mean weight of the primiparous females. This suggests that the female may become sexually mature at 3 years of age.

Among northern fur seals on the Pribilof Islands, the pregnancy rate in 4-year-olds is about 3 percent and in 5-year-olds about 40 percent (Fiscus and Kajimura, 1967). If we assume a somewhat similar condition in the sea otter, it is indicated that a small percentage of females may become pregnant after attaining 3 years of age, i.e., in the fourth year, and that animals 5 or more years of age constitute the important reproducing segment of the population (see also "Implication of Other Observations," p. 245-246).

PREGNANT FEMALES

Table 47 and figure 91 summarize data from 178 females showing evidence of pregnancy. Among pregnant animals, unimplanted pregnancy reached maximum frequency (100 percent) in the fall sample. Implanted pregnancy increased in spring and reached maximum frequency (69 percent) in summer. The high frequency of large (weight class 5) fetuses in summer (50 percent, table 50) and concurrent low frequency of unimplanted pregnancies (31 percent, table 47) indicate, as do the field counts of dependent young, that parturition reaches a peak in summer. Although the fall sample of tracts is small, it demonstrates that parturition in the fall and winter accounts for a minority of births.

Among 137 pregnant females from two samples for which data are available (table 48), it is indicated that annually 17 percent of the pregnant animals became pregnant for the first time and that 83 percent are multiparous.

Location of pregnancy

A record of the uterine horn of pregnancy is available for 97 animals. Although the sample is small, it was gathered unselectively and demonstrates that pregnancy occurs with equal frequency in the right and left uterine horns (table 49). The location of implantation of the conceptus is usually within the center one-third of the uterine horn.

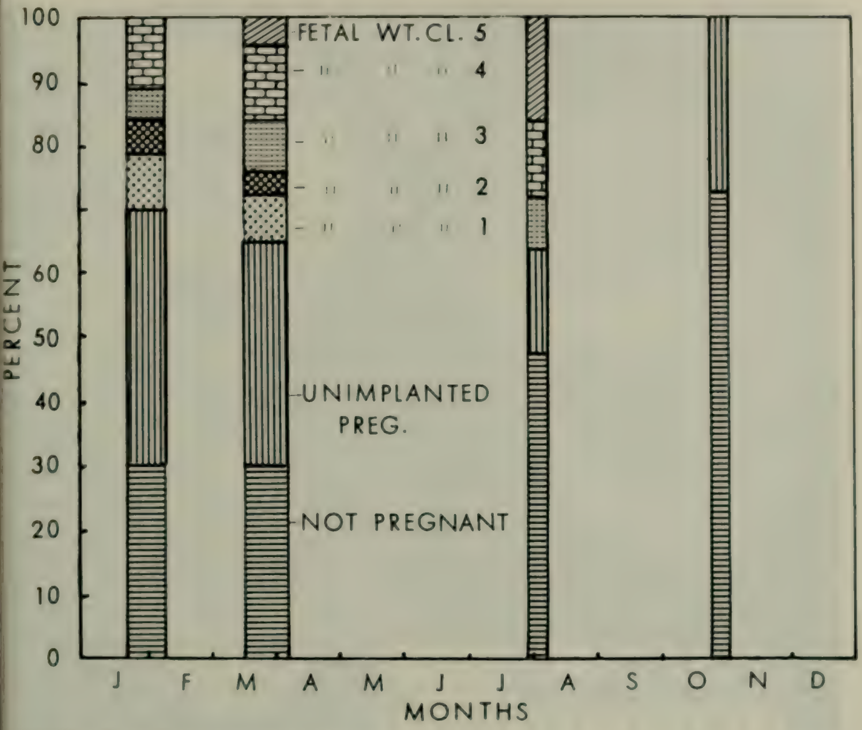


FIGURE 91.—Phases in the reproductive cycle of the female sea otter as revealed by ovary and fetal examinations of four samples of reproductive tracts. Although some of the samples are small, they illustrate that large fetuses and implanted pregnancies predominate in summer and that pregnancy is at a maximum in late winter and spring.

Conceptus size and development

To compare the conceptuses that were recovered from reproducive tract samples, the embryos and fetuses were classified acording to five arbitrarily chosen weight classes following a ogarithmic scale (table 50). The conceptuses ranged in weight rom a fraction of a gram to 1,869 g. (4 lb.). When the weights of etuses taken in different seasons are compared, it is shown that n winter conceptuses of small size predominate and in summer arge fetuses predominate. The series of photographs (figs. 92 and 3) illustrate stages of development. The comparative sizes of the onceptuses in the samples from different seasons were useful in ndicating the timing of certain phases of the reproductive cycle see Chapman's analysis that follows).

The morphology of the female reproductive tract was studied

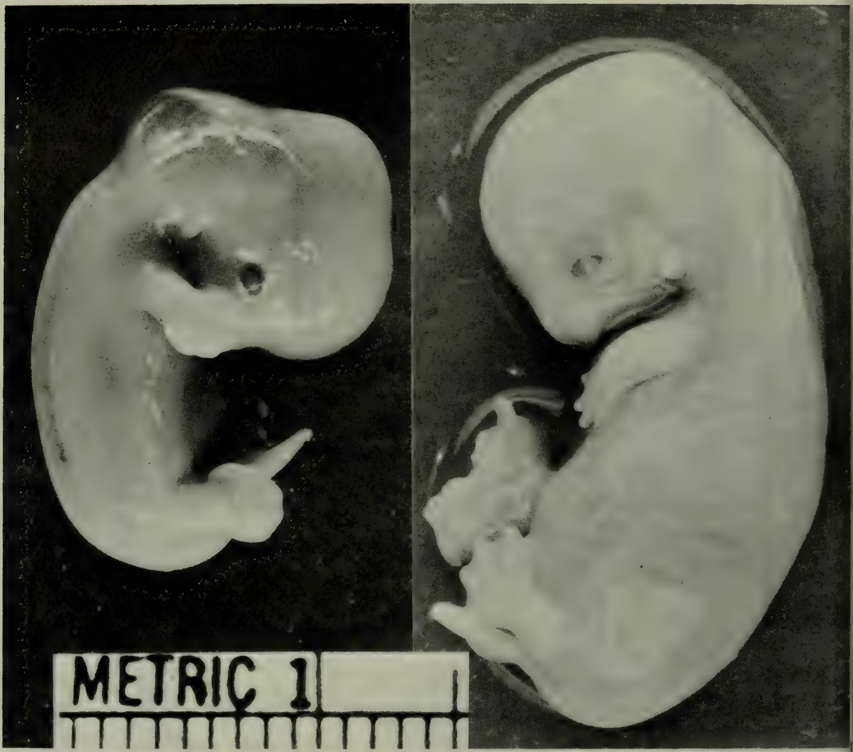


FIGURE 92.—Early fetal stages of the sea otter. Sex could not be determined in either specimen by gross examination, and the age of the fetuses is not known. Differentiation of the front and hind limb buds has barely begun in the larger fetus. Specimens from Amchitka Island, 18 and 19 March 1963: Left—Specimen JEB 63–52, weight 0.692 g., crown-rump length 17 mm. (KWK 65–18–15) Right—Specimen JEB 63–67, weight 1.12 g., crown-rump length 24 mm. (KWK 65–18–9).

and described in detail by Sinha (1965). The development of the fetal membranes, their structures, and evolutionary relationships were studied and described by Sinha and Mossman (1966). The general appearance of the gravid reproductive tract is shown in figure 93.

NONPREGNANT ADULT FEMALES

Spring sample

Although two spring samples (1962 and 1963, table 46) of female sea otters from Amchitka were taken, I studied only the 1963 specimens.

Between 15 March and 2 April 1963, 125 adult female sea otters

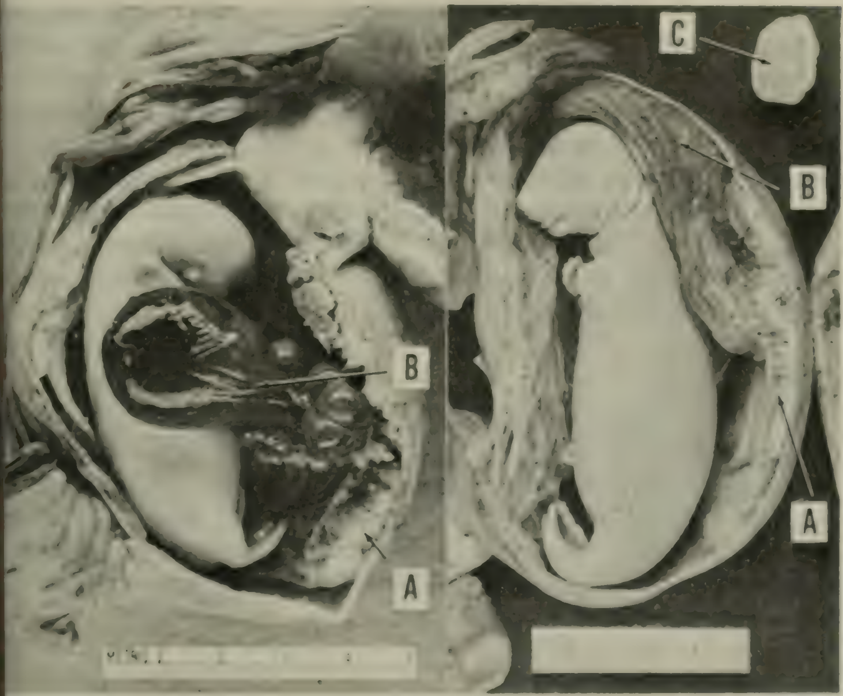


FIGURE 93.—Intermediate fetal development. One side of the uterine wall was removed to show the chorioallantoic placenta (*A*) and the large antimesometrial, pedunculated saclike hematome (*B*). The specimen on the left shows also smaller hematomic pouches surrounding the hemotomic peduncle. The relative size of the ovary is shown. It was sectioned to reveal the large corpus luteum (*C*). Specimens from Amchitka Island: Left—specimen JEB 63-40, weight 11.82 g., crown-rump length 53 mm., sex ♀; taken 17 March 1963. (KWK 65-18-33) Right—specimen ADFG 520, weight 61.95 g., crown-rump length 105 mm., sex ♀; taken 2 August 1963. (KWK 65-13-11) Sinha and Mossman (1966) give a detailed description of placentation in the sea otter.

vere taken and their reproductive tracts were examined (table 1). Thirty-seven (30 percent) showed no evidence of pregnancy no corpus luteum or visible conceptus). Of these, 29 exhibited vidence of being post partum from a few days to perhaps a year. Among these 29 females that were judged to be post partum, 13 45 percent) were accompanied by a pup. The remaining 16 (55 percent) were not, or the pup was not seen, but the female showed natomical evidence of having borne a pup. Although it might be nferred that the loss of young is as high as 55 percent, this is not ecessarily true. Large young, although still dependent on their mothers, may be some distance (±50 m.) from them and thus not associated with the mother by the hunter's observations. Also, large young may have recently become independent.

Among the eight remaining nonpregnant females, four showed no follicular activity or positive evidence of being post partum. One of these was diseased. It possessed a large ovarian cyst (31×15 mm.) The remaining four were multiparous (enlarged uterine horns) but did not show evidence of being post partum and appeared to be approaching estrus (follicles enlarged) or to have recently ovulated.

Summer sample

Among 14 sexually mature sea otters taken between 31 July and 3 August 1963 at Amchitka, 5 (36 percent) were not pregnant. Three of these were post partum. None was accompanied by a pup. (As explained elsewhere, this collection was selectively taken to exclude mothers accompanied by pups.) Two were multiparous inactive but their reproductive tracts revealed no evidence of being recently post partum (table 51).

Fall sample

Among 17 sexually mature females taken between 12 October and 3 November, 13 (76 percent) were not pregnant. Among these, eight (61 percent) were accompanied by young and one was lactating, indicating that a pup had recently been lost. Of the five remaining, three showed no follicular activity or indication of having recently lost a pup. One showed follicular activity indicating a proestrus condition (table 51).

FIELD COUNTS

An effort was made to record newly born young separately from older dependent young. Because of variable field conditions, the results were inconsistent and not useful to this study. Therefore, all young with mothers were grouped as dependent animals.

Counts were made in many areas but only in a consistent way during all field seasons in the Constantine Harbor, Kirilof Point to Kirilof Bay areas. After all of the data from several other areas were studied, it became apparent that because of different conditions in each area the results of counts in one area were not comparable with those made in another. Also, counts made from a cliff top cannot be compared with counts made from a dory. Females with young among coastal rocks may be missed during an ffshore dory count. Also, the number of males, i.e., the degree of exual segregation, varies in different areas (see table 43, Segregaion of Sexes).

I made the field counts from Kirilof Point and vicinity from the ame observation stations at all seasons (table 52). Because they vere made in different years, they cannot be considered strictly omparable but they do constitute the best material available and eneral conclusions are based on them.

In the summer of 1955, Kirilof Point (on the Bering Sea shore f Amchitka), bounded on the east by Constantine Harbor and on he west by Kirilof Bay and having a shoreline of about 5.5 km. 3 nautical miles), was chosen as a study area. I soon found that t was frequented primarily by females, and especially mothers vith young (see Segregation of Sexes). Counts in this area were hus not representative of the ratio of dependent young to indeendent animals in the Amchitka population, but were biased in avor of a high ratio of dependent young to independent (includes oth sexes and all ages other than dependent young) animals.

HASES OF REPRODUCTION

reeding season

Mating behavior (mated pairs, attempted copulation, or copulaion) was observed in all months except October and December. arsh winter weather reduces visibility and I have spent less time n the field in the fall and winter seasons. Barabash-Nikiforov

ABLE 52.—*Sea otters counted along 5.5 km. of shoreline Kirilof area, at Amchitka Island, Alaska*

This area included parts of Constantine Harbor, all of Kirilof Point, and part of Kirilof Bay. This locality is frequented primarily by females and young. Complete counts of Kirilof Point, as well as counts from parts of the area, are included in this table]

Month and year	Number of counts	Independent animals	Dependent young	Total	Percent dependent young	Season mean percent young
anuary 1959	6	37	7	44	16	15
ebruary 1959	7	104	17	121	14	
arch, 1959 and 1962	2	34	5	39	13	15
pril 1959	5	197	39	236	17	
ay 1956	4	164	42	206	20	17
ay 1959	1	62	11	73	15	
une 1956	3	126	23	149	15	
uly 1956	6	258	85	343	25	22
ugust 1955	9	278	59	337	18	
eptember 1955	12	407	83	490	17	24
ctober 1957	3	132	49	181	27	
ovember 1957	11	315	117	432	27	
Total	69	2,114	537	2,651		

(1947) did not observe copulation during October and December.

Data from field observations of breeding behavior and from reproductive tracts give conflicting indications of the period of maximum mating activity. Field observations appear to indicate that most breeding activity occurs in June. By months, observations of breeding behavior were as follows:

January	1	May	9	September	2
February	2	June	17	October	0
March	3	July	1	November	1
April	1	August	4	December	0

Field observations of behavior are hampered in fall and winter by stormy weather conditions. Because comparative field observation time was not available in all seasons, I consider that field observations of mating activity are not quantitatively useful. They are qualitatively useful, however, in demonstrating that breeding activity does occur in all seasons.

Because the frequency of pregnancy in our samples increased from 27 percent in early fall (October) to 70 percent in the January-February sample (table 47), the available data indicate that maximum breeding activity occurs in the late fall to winter period. Further studies, particularly of reproductive tracts taken in fall and winter months, are needed to reveal with certainty the period of maximum breeding activity.

Gestation period

Sinha et al. (1966) demonstrated that after fertilization in the sea otter the blastocyst enters a period of rest, i.e., undergoes "delayed implantation." Thus, presence of a corpus luteum indicates pregnancy whether or not a conceptus is visible on gross examination of the tract. When the "resting stage" is completed, the blastocyst becomes implanted in the mucosa of the uterine horn and proceeds through embryonic and fetal stages of growth.

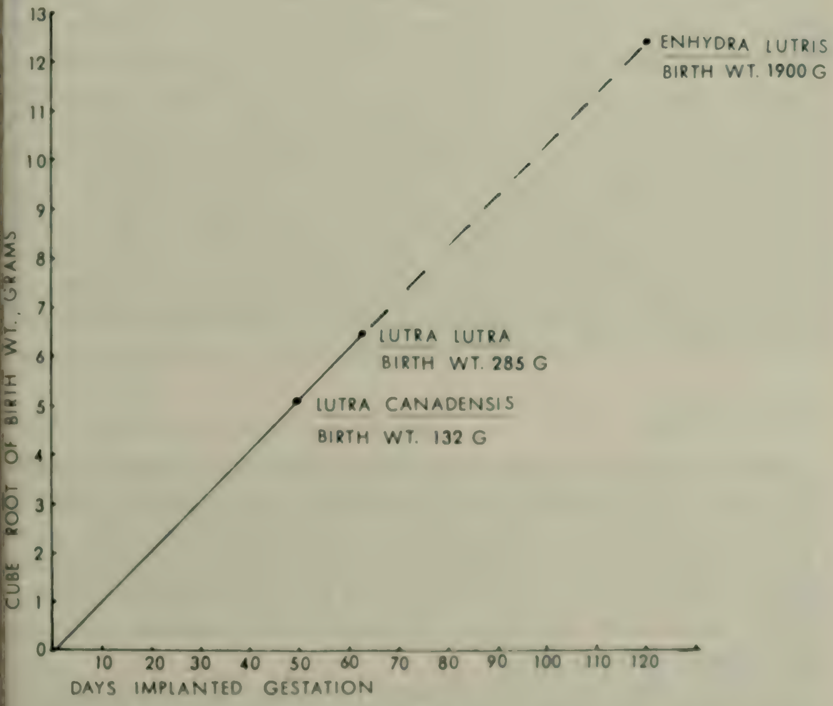
To gain some knowledge of the length of the gestation period and the duration of its unimplanted and implanted stages, data were obtained from the ovaries and conceptuses of 275 reproductive tracts (table 47 and fig. 91).

One method of estimating the gestation period of the sea otter is to assume that during the period of implanted pregnancy the rate of fetal growth may be comparable to that of the European river otter *(Lutra lutra)* and American river otter *(L. canadensis)*. (A more sophisticated method, given below, is employed by Chapman.) The European animal differs from the American river otter and sea otter in that the blastocyst does not undergo a delay in mplantation and the gestation period has been determined to be bout 63 days (Cocks, 1881).

The data of Hamilton and Eadie (1964) show conclusively that he gestation period of the American river otter includes a period f delayed implantation. The data of Liers (1951) appear to indiate that this period may be variable. He recorded extremes of months 18 days to 12 months 15 days in the total gestation period f captive otters.

Huggett and Widdas (1951) showed that during certain phases f prenatal growth the cube roots of fetal weights fall along a traight line. They indicate that an adjustment can be made for he period before the cube root of fetal weights begins to follow straight line. This adjustment, however, is minor and, in estiating the period of implanted gestation in the sea otter, is gnored on the graph (fig. 94).

The weights of two young European otters that were presumably



IGURE 94.—Estimated period of implanted pregnancy. The periods are estimated for the American river otter and sea otter on the assumption that their fetal growth velocities are similar to that of the closely related European river otter (see Huggett and Widdas, 1951).

less than a week old were 285 and 290 g. (Jensen, 1964). If the smaller of the two is presumed to approximate the birth weight and its cube root is plotted according to the method of Huggett and Widdas (1951) for a gestation period of about 62 days, a fetal growth rate line is established (fig. 94). If the full-term fetus weighing 132 g., that was recovered by Hamilton and Eadie (1964), is plotted on the same growth scale as the European otter, it is indicated that the period of implanted pregnancy in the American river otter may be less than 2 months. Liers (1951) states that "The eyes open when the young are about thirty-five days old." This indicates that at birth the river otter is in an early stage of development compared to the sea otter which is born with the eyes open.

To obtain an approximation of the period of implanted pregnancy in the sea otter, it appears reasonable to compare its fetal growth rate with that of its closest relatives. If the cube root of the sea otter weight at birth (generally at least 1,900 g., see Body Measurements) is plotted on the same line of growth, then the indicated period of implanted gestation is at least 4 months. Data from reproductive tracts indicate that maximum breeding activity probably occurs in the fall to winter period and that the maximum number of births occur in the summer to early fall period. The samples indicate that the period of unimplanted gestation in the majority of animals (table 47) extends into the January to April period, i.e., to last for about 6 to 8 months. This would indicate that the total gestation period may be about 10 to 12 months. Because mating and parturition occur during all months, this method of estimating the gestation period from the available data do not permit a more precise definition.

Pupping season

Birth may take place at any season. This was stated by many early sea otter hunters, and confirmed by modern observers (Barabash-Nikiforov, 1947; Fisher, 1940a; Murie, 1940; etc.). I have handled and examined newly born young in all months. Many of these newborn were captured with their mothers during tagging operations and were returned to the mother when she was released after tagging.

Scheffer (1951) raised the question whether there was a season of birth: "The evidence of five specimens . . .is that the young are born in April and May, rather than the year around." Data from our samples indicate that there is a season of maximum birth frequency. The data in table 52 demonstrate that the perentage of dependent young in the population is relatively low n the winter and spring. After the late-winter to early-spring eason of storms, which is accompanied by much mortality among uvenile otters (see Limiting Factors), an increasing number of irths is demonstrated in the field counts. A summer peak in the requency of births is confirmed by high frequency of large fetuses ecovered in that season from reproductive tracts (table 47).

The frequency of nearly full-term fetuses in the samples inreased from none in the January-February sample to 6 percent n the March-April sample and to 31 percent in the May-August ample (table 47). The number of dependent young with mothers lso increased throughout the spring and summer (see table 52, ield Counts).

In the small midsummer sample (August) the fetuses were rge, in weight classes 3, 4, and 5, none were in weight classes 1 nd 2 (table 50).

These data strongly suggest that birth frequency increases in arly spring and reaches a peak in summer. Our samples from the eptember through February period were too small to confirm e field observations of newly born young in every month.

Although the Steller's sea cow *(Hydrodamalis gigas)* is a very ifferent animal from the sea otter, it was also a resident inshore arine mammal. It is interesting that Steller noted (*in* Stejneger, 936, p. 355) that the sea-cow "brings forth their young at all easons, generally however in autumn, judging from the many ew-born seen at that time." The fact of bearing young at all easons, while having a season of maximum birth frequency, may e a case of convergent evolution related to the habitat in which ese animals were sympatric.

lace of birth and fetal orientation

There is no record that the birth of a sea otter has ever been oserved. Fisher (1940a, p. 132) presumed that "The births of the oung otters take place on the kelp beds." This infers that the oung are born in water. Barabash-Nikiforov (1947, p. 97, English anslation), however, saw a mother with a newly born young on ore and recovered the still warm afterbirth.

The place of birth in marine mammals may be related to fetal ientation at birth. For example, in cetaceans birth always occurs water. Slijper (1956) summarized data on the position of the tacean fetus at birth. In 22 observed births, all young were born il foremost. Presumably caudal presentation is a survival factor in an air breathing mammal born under water (Essapian, 1953). Slijper (1956), however, does not subscribe to this theory.

If caudal presentation is a survival factor in aquatic birth and it were the rule in the sea otter, it might be supposed that birth would occur in the water. Among 43 fetuses for which fetal orientation were recorded, delivery would have been cephalic in 22 (51 percent) and caudal in 21 (49 percent). These data indicate that selective evolution for caudal presentation at birth, and by inference for birth in water, has not taken place in the sea otter. By comparison, the fur seal is more specialized for life in the marine environment than is the sea otter but emerges from the water before parturition. Peterson (1965, p. 136) recorded that in 61 percent of 112 observed births the young emerged head foremost. It is thus indicated that birth in the sea otter, as in the fur seal normally occurs on land.

Period between births

Figure 91 and table 47 demonstrate that during the winter and spring when the maximum number of sea otters are pregnant, one-third of the tracts in our sample were nonpregnant. I strongly suspect that all reproductive tract samples are biased toward a low frequency of nonpregnant animals. This assumption is based on three observations: (1) that no female known definitely to be accompanied by a pup was found to be pregnant, (2) that females with young are more wary and secretive than females without young and are thus less available to hunters, and (3) that during hunting operations I noted a degree of reluctance in hunters to shoot a female accompanied by a pup if animals without pups were present. Thus, an unknown degree of bias in favor of single animals, i.e., a high percentage of pregnant animals, is included in all samples. The July to August 1963 sample is particularly biased, since single animals only were selectively killed. At this season the number of mothers accompanied by pups is approaching the annual maximum (see table 52). Thus, the percentage of nonpregnant animals in the adult female population would also approach maximum numbers at this season. This is shown by the sample (fig. 91), but it would be much more apparent had the sample been unselective.

Because the summer sample of reproductive tracts was taken selectively to exclude mothers accompanied by pups it is, in some respects, not comparable with the spring and fall samples. Nevertheless, the following conclusions concerning nonpregnant female sea otters in our samples are indicated. (1) Females accompanied young do not enter estrus. (2) Even if the pup is lost, estrus ay be delayed until after evidence of parturition (lactation, pla- ntal scar, or corpora albicantia) has disappeared or nearly sappeared. (3) In fall there is a maximum number of nonpreg- ınt animals in the population, since many females are accom- ınied by young born in spring and summer. (4) Because the rcentage of proestrous and estrous animals in the nonpregnant pulation is small, it is indicated that impregnation takes place on after the onset of follicular activity.

With the probability of a sampling bias toward a high frequency pregnant animals in mind, it may be considered that more than ie-third and probably at least half of the sexually mature female pulation is always nonpregnant (fig. 91). This coincides with neral observations that the mother sea otter cares for her pup r about a year. When she separates from her young, she may come pregnant and give birth again about 2 years after the ior parturition (see analysis by Chapman that follows).

The period between normal separation of the mother from the ung and the onset of estrus is unknown. If this period is long, e period between births may be longer than 2 years. That the riod between separation from the young and the onset of estrus ay be extended is indicated by the observation that ovaries were active in females which were multiparous but not lactating or companied by a pup and showed questionable evidence (indistinct cent corpus albicantia tissue and slight uterine discoloration) having been post partum for a long time.

te of reproduction

The counts recorded in table 52 were made in an area favored females (see Segregation of Sexes). Data obtained from ani- ıls killed in the Constantine Harbor to the Kirilof Bay areas veal that among 91 animals 19 (21 percent) were males (Segre- tion of Sexes, table 43).

It was shown that for general purposes the sea otter sex ratio ıy be considered 50:50 (see Sex Ratio). If 21 percent of the imals in the field counts were males (from table 52: 2,114 × 0.21 = 444 males, 2,114 − 444 = 1,670 females; males and females total population = 1,670 × 2 = 3,340 independent male and nale;

3,340 + 537 young = 3,877; $\frac{537 \times 100}{3,877}$ = 14 percent, i.e., young independent animals 14 percent dependent young) then the ean annual percent of young in the entire population is 14 percent. Since the young sea otter remains with its mother for about a year, the annual rate of reproduction is 14 percent, or about 16 young born per 100 independent animals per year.

From Chapman's analysis (see later section) it is shown that each 100 adult females in the breeding population produce 50 young per year. Thus, in the adult population (male and female) there are theoretically 25 dependent young per 100 adults of both sexes. It was calculated that 31 percent of the independent animals observed during field counts are juveniles. Thus, 69 percent of those observed are adults. It follows that, with a group of 69 adults there are 17 (i.e., 25 percent) dependent young, or—

	Number	*Percent*
Dependent young	17	14.5
Independent animals:		
Juveniles	31	26.5
Adults	69	59.0
Total	117	100

Information from reproductive tracts, from field counts of dependent and independent animals, and the ratio of males to females in the kill are used in two ways to demonstrate that the annual rate of reproduction of the Amchitka population is about 14 to 15 percent.

Twinning

Barabash-Nikiforov (1947, p. 98) and Snow (1910) report observations of mothers with two young, and reproductive tracts containing two fetuses. Our observations indicate that twinning is unusual. In 278 reproductive tracts taken in 1954–63, 178 of which showed an indication of pregnancy, no twin fetuses were found. One specimen (No. JEB 63–166) taken at Amchitka on 25 March 1963, had well-defined corpora albicantia in both ovaries and darkened scar tissue (placental scars) in both uterine horns. This female was not, however, accompanied by young.

That activity in both ovaries is not necessarily an indication of twinning was shown by one specimen (ADFG 515). Both ovaries contained well-defined corpora lutea but only the left uterine horn contained a conceptus.

In early April 1955, a female and two large young (each about 18–20 lb.) with her were captured on shore at Amchitka. They were held in captivity and liberated at the Pribilof Islands. During the days that the three animals remained in captivity, the adult allowed both young to nurse. She appeared equally permissive to both. She groomed only one of the pups, however, and when the three were liberated together, she ignored one and took on her chest the one she habitually groomed. It was our conclusion that the deserted pup was an orphan toward which this mother exhibited tolerance.

Large young, still dependent on their mothers, will frequently play together for long periods while their mothers are diving for food. If one mother should desert her young at such a time, it is possible that an association such as we observed could occur. Although it is possible that a mother may bear twins, I believe it is doubtful that a mother could feed and groom and successfully bring two young to the stage of independence.

In the northern fur seal *(Callorhinus ursinus)* which, like the sea otter, normally bears one young at parturition and is highly specialized to marine existence, twinning is rare. Peterson and Reeder (1966) summarize data derived from Fiscus, Baines, and Wilke (1964) demonstrating the incidence of twin implantation in the fur seal at 0.14 percent among 4,223 pregnant females examined. In spite of the observation that the young fur seal appears less burdensome to its mother than the young sea otter, no evidence exists to date that a fur seal can successfully raise twins to weaning age (Peterson and Reeder, 1966).

Length of Stages of the Reproductive Cycle

Dr. D. G. Chapman, Chairman, Biomathematics Group, Laboratory of Statistical Research, Department of Mathematics, University of Washington, studied the data obtained from female reproductive tracts and prepared the following analysis:

Analysis of fetal weight data; The procedure of Huggett and Widdas (1951) used to estimate the fetal growth velocity and hence the length of the growth period. Table 53 shows the data of table 50: fetuses classified by weight classes according to time of collection reduced to a percentage basis. The last row in the table is obtained by (1) calculating an unweighted mean of the mean weights in the three periods; (2) finding the cube root of this mean.

The use of percentages in the table and the unweighted means in the

TABLE 53.—*Percent of fetuses in each weight class*

[This table is derived from data in table 50]

Time of collection after July	Class 1	Class 2	Class 3	Class 4	Class 5
nonth	31	15	15	38	0
nonths	18	12	22	35	12
nonths	0	0	22	33	44
an time in months after July	1.7	1.9	4.0	3.5	[illegible]
an of cube root of weight	0.74	2.21	3.27	7.18	11.45

calculation are necessary to give equal representation to all times of the year. A regression line fitted to the cube root of the weights against the mean time in months give a regression coefficient of

$$a=2.292 \text{ per month}$$

or on a daily basis

$$a=0.076$$

This is an estimate of the specific growth velocity of Huggett and Widdas (1951). In view of the very small samples obtained over all parts of the year except the January to April period, it is subject to considerable sampling error and it seems reasonable to round the estimate to 0.08. While this growth velocity is somewhat below the value calculated for the European river otter, it is quite close to values calculated for the northern fur seal (0.085 has been calculated by Chapman, unpublished manuscript).

If 1850 g. is used as an average fetal size at birth, the estimated period of fetal development after establishment of the fetus is,

$$\frac{\sqrt[3]{1850}}{.08} = \frac{12.3}{.08} = 154 \text{ days}$$

or approximately 5 months.

It is also necessary to estimate the length of the gestation period during which the blastocyst is unimplanted. From table 54 we have the numbers and percentage of pregnant animals with an unimplanted blastocyst and a conceptus during the four seasons.

It might be argued that lesser weight should be given to the two shorter periods, January to February and March to April. If the results of these two periods are averaged, and this average is incorporated into an overall unweighted average, the result is essentially the same. (The average so computed would be 61 percent versus the 60 shown in table 54.)

It thus appears that the period during which the blastocyst is unimplanted is half as long again as the implanted period, or about 7½ months. The full gestation period will also include the period required for establishment of the embryo, i.e., the period before linear growth is established. Huggett and Widdas (1951) indicate a rough procedure to estimate this but it is not known whether their values apply to animals that exhibit delayed implantation. If about ½ month is allowed for this period, it follows that the estimated total length of the period of gestation is about 13 months.

The period during which the female sea otter is not pregnant (lactating and resting period) can be estimated similarly from the data from table 47. This table shows that the percent nonpregnant in the four periods noted is 30, 30, 48, and 73, respectively. In this case the weight to be given to the two first periods does make a difference. The average of the four percentages is

TABLE 54.—*Frequency of unimplanted and implanted pregnancy, by season*

[Data from table 47]

Sample period	Number animals with unimplanted blastocyst	Number animals with conceptus	Percent unimplanted
January, February	35	26	58
March, April	49	49	50
May–August	4	9	31
September–December	6	0	100
Unweighted average			60

5, while the average of the three seasons, if January, February, March, and pril are pooled into one value, is 50.

If the length of the gestation period is about 13 months, the first average bove, i.e., 45 percent, would imply an 11-month period for lactation and rest-ng and a 2-year total cycle. The other average, 50 percent, would imply a 3-month lactation and resting period or a total 26-month cycle. This seems ss probable, though it could be the average of a breeding group in which ome proportion of the animals miss being impregnated at the first oppor-unity after the end of lactation and thus lengthen the average cycle. It is lso possible that the estimates of the length of the gestation period are high ue to sampling errors and that both gestation and lactation plus resting eriods are 12 months in length.

It thus seems that the best estimates available at present are as follows:

Lactation plus resting	11–12 months.
Unimplanted period	7–8 months.
Implanted fetus	4½ to 5½ months.
Gestation period	12–13 months.
Total length of reproductive cycle	2 years.
Average birth rate mature female	0.50.

MPLICATION OF OTHER OBSERVATIONS

Recruitment and mortality rate: The observations on the proportion of rimiparous animals among pregnant animals (17 percent, table 48) taken gether with the 2-year cycle indicates that the recruitment rate among ature females is 0.085 per year. If the mature female herd is nearly stable size, this will also be the mortality rate of this component of the popula-on. This is relatively low but only slightly lower than the corresponding te among fur seals.

Proportion of juveniles and length of juvenile stage: If 50 percent of the ature females give birth each year and nurse the young animal for nearly year (say 10 months), this implies the ratio of dependent young to mature males is ½ × $^{10}/_{12}$ or 0.42. Extensive field observations (table 52, cf. also scussion) show the ratio of dependent young to independent females is $\frac{7}{70}=0.32$.

The independent females include both mature and juvenile animals. If it is sumed that the survival rates of both of these groups is 1–0.085 (=.915) *ter the initial transition from dependence to independence*, then a com-arison of the two ratios given above shed light on both the proportion of veniles in the herd and the length of the juvenile stage.

For denote by

Y=dependent young (of both sexes)

J=juveniles (females)

A=adults (females)

en the above two ratios are:

$$\frac{Y}{A}=0.42$$

$$\frac{Y}{A+J}=0.32$$

so that

$$\frac{A+J}{A}=\frac{0.42}{0.32}=1.31 \text{ whence } 1+\frac{J}{A}=1.31$$

or

$$\frac{J}{A}=0.31 \qquad (1)$$

Now let J_o=number of juveniles in their first year after dependency let n= number of years in juvenile stage

$$J=J_o+J_o(.915)+\ldots J_o(.915)^{n-1}$$

$$=\frac{J_o}{1-.915}(1-(.915)^n)$$

Also $A=J_o(.915)^n+J_o(.915)^{n+1}+\ldots$

$$=\frac{J_o(.915)^n}{1-.915} \qquad (2)$$

so that

$$\frac{J}{A}=\frac{1-(.915)^n}{(.915)^n} \qquad \text{or from (2)}$$

$$0.31=\frac{1}{(.915)^n}-1$$

$$1.31=\frac{1}{(.915)^n}$$

or

$$(.915)^n=\frac{1}{1.31}=.763$$

Whence n = 3 years approximately. This is the estimated length of the period between the end of dependence and maturity for females.

SUMMARY AND CONCLUSIONS

1. It is indicated that breeding activity reaches a peak in fall, but breeding activity was observed in all seasons.
2. Unimplanted gestation is estimated to last for 7 to 8 months.
3. Implanted gestation is estimated to last for 4½ to 5½ months.
4. The total gestation period is estimated to last 12 to 13 months.
5. The period between births, i.e., total length of the reproductive cycle, is about 2 years.
6. The average annual birth rate among mature females is 50 percent.
7. Parturition occurs in all months, but a minority of births occur in fall and winter months. Parturition reaches a peak in summer, and large fetuses occur with greatest frequency in summer.
8. Dependent young occur with greatest frequency in fall and with least frequency in late winter and early spring. In fall, unimplanted pregnancy reaches greatest frequency.
9. Birth normally occurs on land.

10. Caudal and cephalic presentation of the fetus occurs with about equal frequency.

11. Twinning is possible but rare, and if twins are born there is no evidence to show that both survive.

12. Females accompanied by young or showing positive evidence of parturition do not normally enter estrus.

13. Low frequency of estrous and proestrous females among nonpregnant females at all seasons indicate that impregnation occurs soon after the onset of follicular activity.

14. Annually 17 percent of the pregnant animals are pregnant for the first time and 83 percent are multiparous.

15. Pregnancy occurs with equal frequency in each uterine horn.

16. The annual rate of reproduction in the total population is estimated to be about 14 to 15 percent (i.e., about 16 young born per 100 independent animals of both sexes and all ages).

17. It is estimated that the female sea otter reaches sexual maturity at age 4 years (3 years after becoming independent).

Reproduction in the Male

Observations of courtship behavior in all seasons and the occurrence of newborn young in all months indicate that male sea otters may be sexually active at any season.

A preliminary histological study of testes was made of 40 sea otters taken in the January to April period in 1958, 1959, and 1962. These specimens indicate that spermatozoa are produced when the testes attain a weight of about 13 to 14 g. Spermatozoa are probably not produced by animals having a body weight of less than 50 lb., but most of those weighing 55 lb. and all of those weighing 60 lb. or over may produce spermatozoa.

Dr. Edward C. Roosen-Runge, Department of Biological Structure, University of Washington Medical School, Seattle, kindly examined the histological specimens of sea otter testes and contributed the following information concerning the adult:

> No quantitative evaluation was attempted. Spermatogenesis was evaluated by the stages of germ cells present. The last stage of spermatogenesis is that in which the late spermatids (with dense and elongate heads) are lining the lumen of the tubule. If an appreciable number of tubular sections were found containing this stage or stages immediately preceding it, it was assumed that many spermatozoa were liberated at this time from this testis. If many stages of spermatogenesis were found, but few of the very late ones, it was assumed that there was a slowing down or a standstill somewhere in the development of germ cells or that some periodicity occurred in the liberation of sperm.

The material examined appeared to indicate quite strongly that there was such a periodicity. All adult animals showed a germinal epithelium in a state of active production of germ cells, but not all showed an appreciable number of late stages of spermatogenesis. No animal indicated as "old," [animals having well-worn teeth were arbitrarily classified in the field as old] showed any signs of diminished sperm output; in fact, all of these animals (3) showed *many* late stages of spermatogenesis.

Two cases (62–92 and 62–228) were probably hypotrophic. Both were poorly preserved (hypotrophic testicles are commonly more difficult to preserve well). It appeared to me that these two cases are possibly significant. They may indicate either a fairly high percentage of males with degenerative testicles and consequently low fertility, or they may indicate a periodicity in the spermatogenic activity which would appear more pronounced when specimens taken throughout the year are investigated. Both hypotrophic testicles showed hypotrophic Leydig cells.

The Leydig cells of the normal, adult sea otter testis appear to be aggregated in huge masses around the rete channels and almost form an "endocrine organ" in this location. From there, long strands of these cells penetrate into the septa, usually in very close apposition to thin-walled veins. The rete itself is fortified very strongly with a coarse network of collagenous fibers. The general structure of the seminiferous tubules is entirely typical for mammals.

One conclusion that appears justified on the basis of the testes examined is that the production of spermatozoa in the sea otter exhibits a mild or modified periodicity. There is no indication that a distinct seasonal periodicity in sperm production exists, as in many distinctly seasonal breeders, or that there is continuous production of sperm as in the rat. A comprehensive study of reproduction in the male sea otter remains to be done.

LIMITING FACTORS

The sea otter is highly specialized to occupy a limited aquatic environment. The feeding habitat lies between the beach and the 30-fathom curve. Its specialized characteristics which confine it to this inshore area offer both advantages and disadvantages to its survival. The advantages are that it may usually find shelter from violent storms and that its prey species, unlike the wandering populations of the pelagic prey organisms of other marine mammals, are localized. A disadvantage, though, is that population growth and expansion of range may be hindered and a local population, isolated by broad expanses of deep water, may overutilize food resources. In times of stress, a large isolated population may suffer heavy mortality caused primarily by starvation.

The sea otter's natural enemies are few. Depredation by man and natural attrition resulting from overutilization of food resources are the mortality factors that limit population size.

Mortality among sea otters was studied during the winter-spring period of environmental stress only at Amchitka Island. In other seasons, different areas were visited and an effort was made to find beach remains that would give an indication of the magnitude of winter-spring mortality.

Amchitka differs from most areas inhabited today by sea otters. It and the other densely populated Rat Islands are isolated from other areas of sea otter habitat by broad, deep passes and the whole island group is densely populated. Emigration of otters from Amchitka appears to be insignificant. Emigration from a crowded population at Kanaga Island was observed (see Distribution and Numbers). Unfortunately, this island is difficult for biologists to reach and no observations of mortality there are available.

The Shumagin and Sanak Islands groups, which I visited, have relatively small otter populations in proportion to available feeding habitat when compared to Amchitka. The observations obtained from these three areas are presented.

Natural Mortality

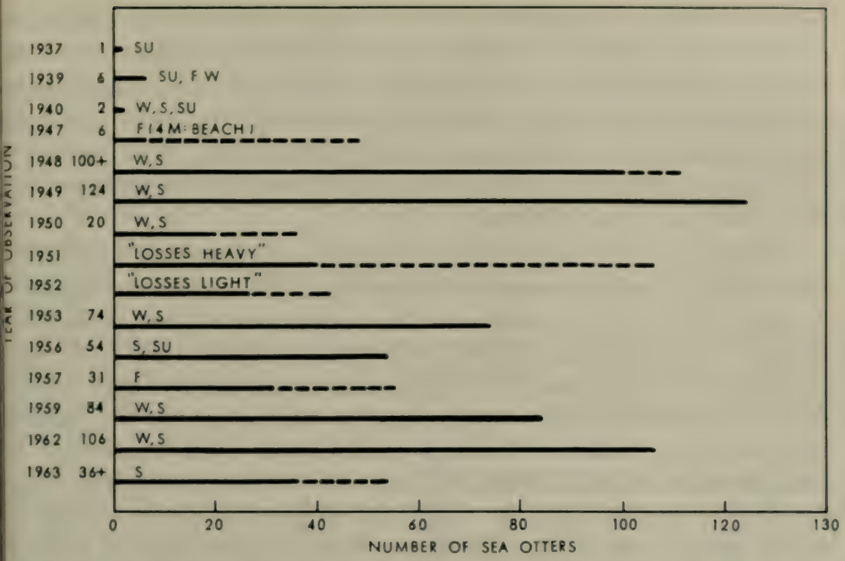
Data are not available to indicate exactly when the regular annual occurrence of considerable late-winter, early-spring mortality among sea otters on Amchitka Island began. Natives who trapped foxes there in 1938–39 reported that "many" dead sea otters were found on beaches in that winter. Between 10 July 1939 and 15 January 1940, however, a careful search revealed only six skeletons on beaches (Loy, 1940). Sea otter wardens J. B. Mangan and G. Ritter, who were on Amchitka from 1 February to 5 September 1940, reported salvaging only "two sea otter skins and skeletons" (Amchitka Island Report, September 5, 1940, U.S. Fish and Wildlife Service files, unpublished).

During the years that Amchitka was occupied by military forces, 1941–47, no reports of unusual sea otter mortality were made. V. B. Scheffer and I visited Amchitka on 12 November 1947 and recorded (field notes) that in walking about 4 miles of beach we found the remains of six sea otters. At the time we attributed these deaths to military personnel occupying the island, two of whom we saw target practicing along the beach. Only a fraction of the beaches where dead sea otters were found in subsequent years was examined.

In the light of later experience on Amchitka, I am inclined to believe, on the basis of what I saw on that one day in 1947, that considerable natural mortality occurred in the winter-spring period of 1946–47. In the late-winter, early-spring period of 1948, Elmer Hanson, a civilian employed by the Army on Amchitka, estimated that more than 100 otters died on Amchitka beaches. Jones and Hanson recorded 124 dead otters on the beaches in the late-winter, early-spring period of 1949 (Jones, R. D., narrative reports of 1 January to 30 April and 1 July to 30 August 1949, unpublished). Both Jones and Hanson spent much time on Amchitka during or after World War II. Neither remembers observing a significant number of dead otters on beaches before 1948. Thus, it appears that an annual late-winter, early-spring "die-off" began in the late 1940's. All available counts and estimates are shown in figure 95. An analysis of observed mortality from 1955 to 1963 at Amchitka is presented in the following pages.

Studies conducted 1955–63

During the 1955–63 study period, I repeatedly surveyed the same beaches that were searched for dead otters by previous observers. The majority of moribund otters haul out above the high



IGURE 95.—The counts (solid line) and estimates (broken line) of dead sea otters on Amchitka beaches indicate the order of magnitude of annual mortality. Except for the counts of 1949, 1959, and 1962, the figures are only roughly comparable. The information was obtained from unpublished reports in Fish and Wildlife Service files: 1937, C. L. Loy and O. A. Friden; 1939, C. L. Loy; 1940, J. B. Mangan and G. Ritter; 1947, V. B. Scheffer and K. W. Kenyon; 1948, E. C. Hanson; 1949, 1950, 1953, R. D. Jones; 1956, 1957, 1959, 1962, K. W. Kenyon; 1963, J. E. Burdick; and from Rausch (1953). The season of observation is indicated as follows: W=winter; S=spring; SU=summer; and F=fall. In no case were all beaches searched regularly. Counts were obtained mainly on the southeastern half of the island. This data is useful only in illustrating the relative magnitude of mortality in different years.

ideline and die on shore. Dead sea otters float and if they die in he water they usually wash ashore. Thus a high percentage of hose that die in study areas may be found if beaches are searched ystematically and frequently.

To study annual mortality as a factor in population dynamics, nd to ascertain its magnitude and understand its causes, I made n effort to gather comparable mortality data during five trips to mchitka.

lethods of study

Certain beaches on the eastern half of Amchitka were searched ystematically. Observations are available for each month of the ear. Most dead otters were on or near favorite hauling-out beaches. Other accessible beaches in the study area were searched periodically but less intensively than the favored hauling-out areas.

Each dead animal was autopsied. Specimens—including skins, skulls, bacula, reproductive tracts, stomachs, and organs appearing pathological—were preserved when practicable. The extent of decomposition determined the amount of information and specimen material that was obtained.

Because it was important to determine the period of greatest mortality, it was necessary to ascertain the usual progress of decomposition, and to estimate the approximate time of death of animals that had been dead for varying periods. Up to a point, this procedure was useful. The time of death for skeletal remains found in midsummer, however, could be placed only to the previous winter-spring season. During periods of high mortality the beaches were searched weekly. Thus, the week of death was known for many animals and the month of death for others. Data for otters that had been dead for more than ½ to 2 months were recorded, but because of uncertainty most of these records were excluded from those aspects of the study which required more exact data. Each carcass was removed from the beach after needed data were recorded and specimens taken from it.

Average daily air temperatures in winter infrequently exceed 36° F., and spring and fall average daily air temperatures above 49° F. are unusual. For this reason, otter carcasses decompose slowly on Amchitka beaches. The study was complicated when scavengers (Bald Eagles and rats *(Rattus norvegicus)*) mutilated carcasses, sometimes preventing the gathering of certain data.

Results

Between July 1955 and April 1963, approximately 15 months were spent on Amchitka. During six study periods, a total of 331 dead otters found on the beaches were examined. Because data from certain individuals were incomplete, these are eliminated, where appropriate, from the following discussions of different aspects of mortality.

THE TIME OF MORTALITY

It would be ideal, in a study of sea otter mortality, if data could be gathered during some period of consecutive months for several years. This could not be done, so the data from various seasons in different years were used to present a composite picture of the annual cycle of mortality. The mortality study included parts of different seasons during the six field study periods. Two seasons, 1959 and 1962, included the entire period of greatest mortality.

Data gathered in midsummer presented fragmentary evidence of the magnitude of mortality that occurred in the preceding winter-spring period. Natural decomposition of dead otters, storm waves that sweep high onto beaches, and scavengers scatter, bury, and break up skeletal remains. By midsummer of 1955, little skeletal material remained on beaches to indicate the extent of mortality that I observed briefly in late March and early April of that year.

Available data indicate that maximum mortality among sea otters at Amchitka occurs annually during the winter and early spring (fig. 96). At this time of year the Aleutians are subject to frequent and often violent atmospheric storms, and also prolonged periods of high seas. In 1962, moderate weather conditions prevailed from mid-January to mid-February and mortality up to that time was insignificant. From this time on, weather conditions were stormy. Mortality increased rapidly after 20 February and remained high until 25 March. A search of all study areas during the last week of March revealed only three freshly dead otters (fig. 97).

In 1959, late winter and early spring were less stormy than in 1962. Appreciable mortality did not occur until early March, but t continued at a high rate until mid-May. During the intensely tormy 1962 season, 106 dead otters were found in only 2 months n the same beaches where 84 dead otters were found during the omparatively mild 1959 season (fig. 96). Thus, it appeared that he magnitude and the time of greatest mortality varied in accordnce with the stresses exerted on the animals by the environment.

AGE-SPECIFIC MORTALITY

No technique is known by which the chronological age of a sea tter may be determined. On the basis of body size, suture closure, nd dentition, however, certain age classifications are roughly ndicated. In this discussion I will distinguish only between immature and adult animals. Table 55 summarizes available data, nd indicates that immature otters (fig. 98) constitute about 70 ercent of the average annual mortality. Among adults, most of hose found dead or dying show signs of aging (fig. 99), such as rizzled pelage and severe dental attrition.

The juveniles weigh from about 10 to 30 lb. and are still in the ompany of their mothers when the winter period of storms begins. Large juveniles, although capable of obtaining food by

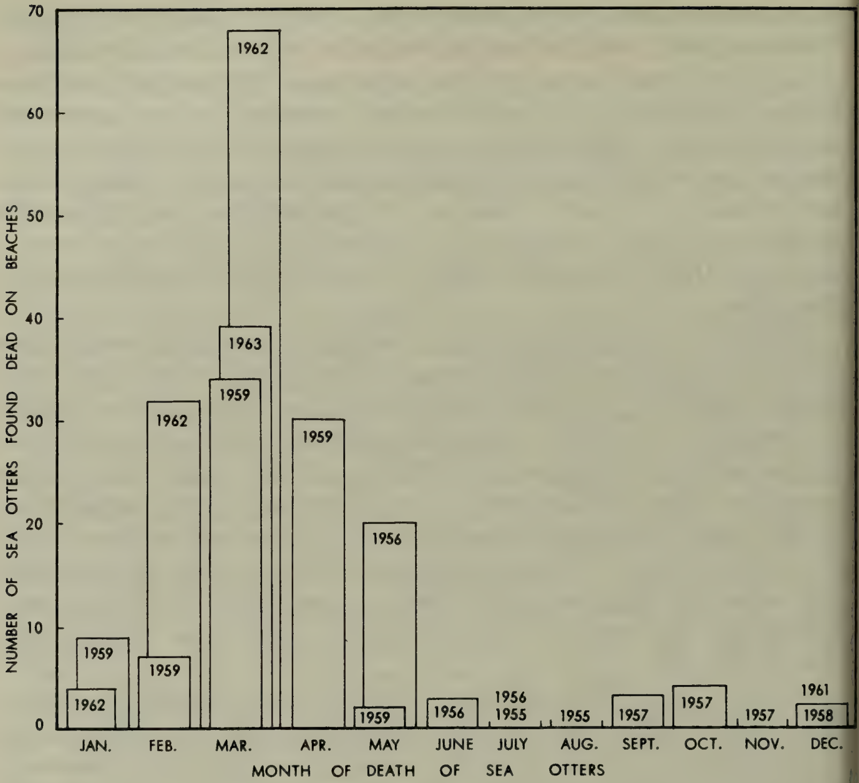


FIGURE 96.—Observed mortality of sea otters at Amchitka Island, 1955–63. Each bar represents the number of otters that were found dead and were estimated to have died in the indicated month and year. Otters dead so long that the month of death could not reasonably be estimated are excluded. Data from 259 dead otters were used in this graph. No freshly dead otters were found in June, July, or August of 1955, in July of 1956, or in November of 1957.

diving, habitually beg for and receive food from the mother. The result of this behavior is that mothers are unable to obtain sufficient food for themselves and their large offspring during periods when heavy seas render food gathering difficult. For this reason, many mothers desert their large young at this season of stress. Deserted juveniles were seen searching and screaming for their mothers in the late-winter, early-spring period.

For example, a mother and a pup, weighing about 12 lb. (5.4 kg.), were captured together and tagged on 15 February 1962. When released they swam off together. Both appeared thin but in normal health. On 18 February, the juvenile was found wander-

TABLE 55.—*Mortality of sea otters, by age and sex, at Amchitka Island, Alaska, 1956–63*

[Certain specimen records are eliminated from this table because inadequate data or specimen material were available]

Observation period	Juvenile								Adult								Grand total
	Males		Females		Sex?		Total		Males		Females		Sex?		Total		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
5 May–26 July 1956	21	39	7	13	10	18	38	70	7	13	3	6	6	11	16	30	54
10 October–11 December 1957	3	10	2	6	10	30	15	48	9	29	—	—	7	23	16	52	31
21 January–20 May 1959	26	31	16	19	10	12	52	62	21	25	9	11	2	2	32	38	84
19 January–4 April 1962	51	48	23	22	7	7	81	76	10	9	15	14	—	—	25	24	106
10 March–12 April 1963	13	36	12	33	9	17	34	94	1	3	1	3	—	—	2	6	36
Total	114	36	60	19	46	15	220	70	48	16	28	9	15	5	91	30	311

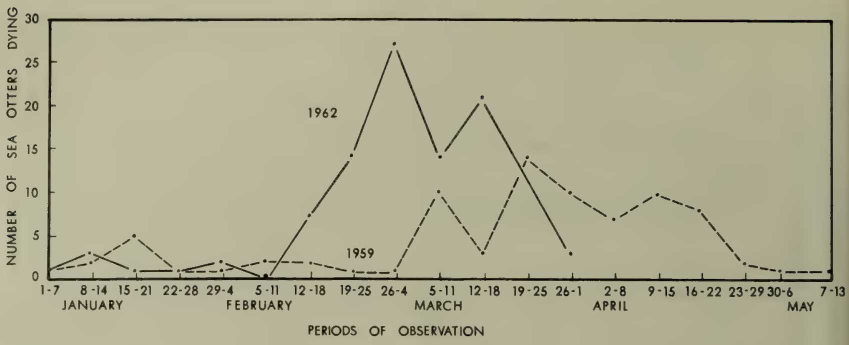


FIGURE 97.—Mortality of sea otters at Amchitka Island during weekly intervals through periods of high mortality in 1959 and 1962.

ing about alone, crying, very weak, and near death from starvation. The mother was found dead on 19 March. It might be concluded that even after deserting her pup, she was unable to regain the strength she sacrificed during storms while attempting to meet the food demands of both herself and her pup. Another pup (weighing about 17 lb., 7.7 kg.) was captured, tagged, and released together with its mother on 27 February 1962. The pup was found dead and emaciated on 5 March.

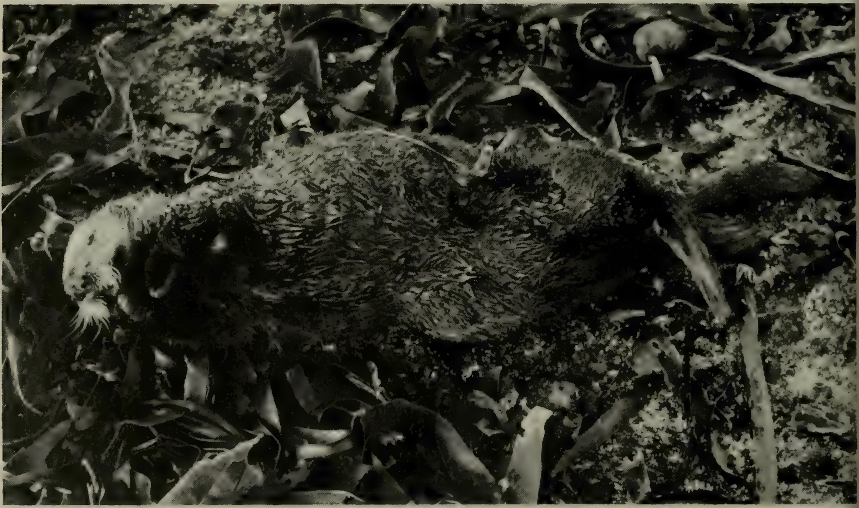


FIGURE 98.—A moribund juvenile sea otter. During the late winter and early spring season of stormy weather starving juveniles haul out on shore and die. Enteritis is usually a terminal symptom. This animal illustrates the final comatose stage that occurs shortly before death. Amchitka Island, 26 February 1962. (KWK 62–17–22)

IGURE 99.—This aged male sea otter sought escape from a high wind in a sheltered cove. It was in a final stage of starvation, appeared to be blind or nearly blind, and showed severe dental attrition. Most adults found dead exhibited similar symptoms of aging. Amchitka Island, 26 February 1962. (KWK 62–17–3)

Small helpless pups are present in the Amchitka population at ll seasons. They were, however, seldom found dead on beaches. wo were found in 1959 and two in 1962. Three reasons are uggested to explain why few are found dead. (1) Mothers habitu-lly give more care and attention to small pups than to large uveniles. (2) Small pups require comparatively little food and iothers are able to supply their food needs without undue strain n themselves. (3) If a small pup dies it is retained by the mother ntil it becomes saturated with water. When she finally deserts ie body it may sink and not be found on the beach.

Among captive otters we observed that when a mother otter is iven a reduced ration of food she steals food from her pup. This ehavior suggests that when stormy weather and reduced prey opulations make it difficult to obtain sufficient food for herself nd her pup, she deserts her large juvenile at an earlier age than ie would during moderate summer weather when food gathering less difficult.

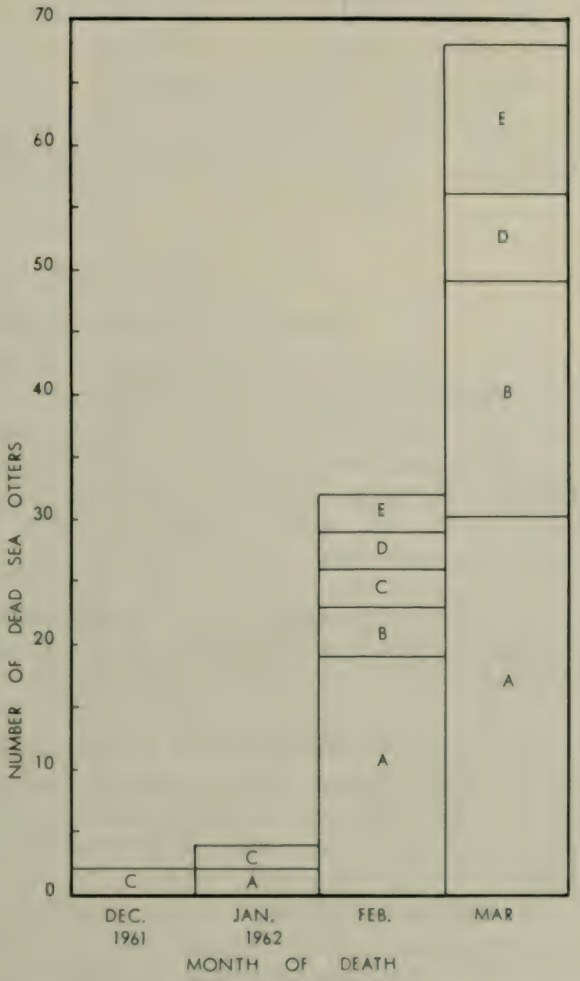
Among animals found dead, the percentage of juveniles in the ifferent study periods varied from 48 to 94 percent. Mortality data obtained in summer, fall, and early winter are not directly comparable with data obtained in late winter and early spring. Between 1 October and 11 December 1957, 48 percent of the remains found were juveniles. The remains of most dead animals were judged to have lain on beaches since the previous winter-spring period. Only seven were judged to have died in September or later. There is a greater probability of finding remains of adults because they are more durable than remains of immature animals. The skeletons of juveniles, unless in sheltered locations well above tide line, suffer environmental attrition more rapidly than the harder bones of adults. Six months or more after the mortality period, remains of many juveniles had disintegrated and were not among the bones still on beaches. This probably explains why juveniles did not predominate.

In 1963, when juveniles composed 94 percent of the dead animals, the study period was 10 March to 12 April. The data from 1962 indicate that mortality among adults may increase as the period of high mortality advances (fig. 100). In January and February 1962, before the height of the mortality period, adults constituted 16 percent of the animals that died. During and after the period when the mortality reached its peak in March, 39 percent of animals that died were adults. This might indicate that adults are better able to withstand environmental stresses than immature animals recently separated from mothers. In 1963 the period of greatest adult mortality may not have been included in the study period, and a disproportionately high mortality of juveniles was indicated by the available data. The 1959 data show, however, that the mortality among adults may, in some years, be high throughout the period of increased mortality (fig. 101).

The 1959 and 1962 study periods are the only two which spanned entire periods of greatest annual mortality (fig. 97). Therefore, the proportion of juveniles (60 and 75 percent, respectively) to adults is probably more representative of the usual mortality pattern.

SEX-SPECIFIC MORTALITY

More males than females were found dead on beaches. Among juveniles, the disparity was greater than among adults. Rausch (1953) noted in his 1951 and 1952 investigations that "the heaviest mortality occurred . . . in subadult males." The raw data from the remains I examined, however, tend to exaggerate this difference. The accurate determination of sex by the examination of juvenile skulls or other bones is perhaps impossible. If a carcass was



IGURE 100.—Age and sex of sea otters dying in the winter-spring period of 1961–62. *A*—juvenile male; *B*—juvenile female; *C*—juvenile, sex unknown; *D*—adult male; *E*—adult female.

nutilated by scavengers and the reproductive organs removed, he sex of the animal was in question. On partially mutilated carasses, the likelihood that a male might be identified was greater. agles, for example, usually remove the viscera first. The genitalia f the females are easily taken, but the baculum of the male is ttached to the ischium by a strong ligament composed of the schio- and bulbo-cavernosus muscles. These parts may remain ttached to the skeleton, identifying it as a male for weeks longer

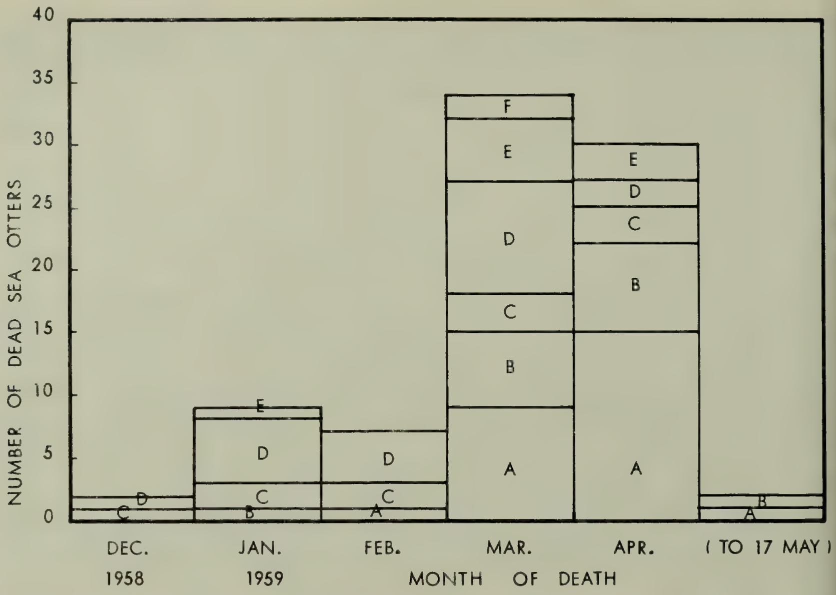


FIGURE 101.—Age and sex of sea otters dying in the winter-spring period of 1958–59. *A*—juvenile male; *B*—juvenile female; *C*—juvenile, sex unknown; *D*—adult male; *E*—adult female; *F*—adult, sex unknown.

than a female may be identified. Because of this situation and to avoid a bias in favor of males, only the freshly dead beach specimens found in 1959, 1962, and 1963 are listed to give the best available indication of the sex ratio of otters dying during the period of environmental stress (table 56).

Among 117 juveniles examined on beaches in the three seasons, 58 percent were males. In 1963, the sex ratio was 50:50, but in this year the field study was abandoned while the high mortality period was probably still in progress and the results may not be representative.

That males are not as hardy as females was repeatedly demon-

TABLE 56.—*Age and sex of otters found freshly dead on Amchitka beaches*

Year	Juvenile					Adult					
	Males		Females		Total number	Males		Females		Total number	Grand total
	Number	Percent	Number	Percent		Number	Percent	Number	Percent		
1959	21	57	16	43	37	13	68	6	32	19	56
1962	36	62	22	38	58	8	38	13	62	21	79
1963	11	50	11	50	22	1	50	1	50	2	24
Total	68	58	49	42	117	22	52	20	48	42	159

rated when both sexes were held captive under the same con- tions. A similar situation was suggested in the northern fur al. Chapman (*in* Abegglen, Roppel, and Wilke, 1960) estimated at in the first 3 years of life females outsurvived males by a tio of 2 to 1. Studies since then indicate that the ratio may be ly 1.25 to 1 in favor of females (Chapman, unpublished manu- ript).

ORTALITY FACTORS

hysical characteristics and food supply

The terminal conditions observed in a high percentage of otters und dead on Amchitka beaches are emaciation and hemorrhagic teritis. Enteritis may, however, occur in the final hours before ath after other conditions have doomed the animal.

Sea otters found dead on beaches during the late-winter and rly-spring period of high mortality may be divided into two imary groups: (1) Those whose death was apparently caused an injury in rough seas, or disease, and (2) those which showed idence of starvation and finally exhibited symptoms of enteritis. any dead animals cannot be placed positively into one group or e other. An emaciated and weakened animal is more subject to jury by large breakers than a strong one. An animal obviously lled by an injury might have died soon of starvation.

The actual cause of death of many animals cannot be determined cause of decomposition. Table 57 lists observed conditions which ay have caused death of otters that might be considered to be in oup (1) above. The section "Parasites and Miscellaneous Dis- ses" gives additional data on mortality recorded by Dr. Robert L. usch in 1952 and more detailed information on several speci- ens that were examined in the laboratory.

The dead animals which fall into the second group are of the eatest interest from the point of view of population studies. ost of these may be separated into two age groups: (1) Juveniles, any of which approach subadulthood and, (2) old animals having rn teeth and often showing other indications of advanced age, ch as gray pelage about the head, chest, and abdomen, and im- ired vision caused by injuries or senile cataracts. In the 1959 udy period a particular effort was made to record pertinent ta from 83 individual otters found dead on beaches. The infor- ation is summarized in table 58.

Juveniles and old adults had two characteristics in common at ath. Both lacked body fat and both showed a high incidence of fective teeth. In the case of the young animals, 50 percent ex-

TABLE 57.—*Abnormal conditions found in sea otters that died on beaches of Amchitka Island, Alaska*

Collection number	Age	Sex	Date	Condition
59–68	juv.	♂	15 Mar. 1959	Fractured skull.
59–92	ad.	?	29 Mar. 1959	Bruised head.
36–56	juv.	♂	31 May 1956	Bruises, blood clots around head and neck.
B20–57	juv. (pup)	♂	30 Oct. 1957	Broken neck.
59–3	juv.	♀	26 Jan. 1959	Nondraining abscess dorsally in neck and head.
47–56	juv.	♀	17 June 1956	2 broken ribs.
59–73	juv.	♀	14 Mar. 1959	Extensive body bruises and swellings.
59–49	ad.	♂	5 Mar. 1959	Body bruises perforated intestine.
59–100	ad.	♂	31 Mar. 1959	Internal hemorrhage—quantity of blood in abdominal cavity.
59–155	juv.	♀	6 May 1959	Perforated intestine and intussusception of small intestine.
44–56	ad.	♂	11 June 1956	Bruises in genital area.
59–34	ad.	♂	20 Feb. 1959	Bruised penis.
62–241	ad.	♂	12 Mar. 1962	Penis swollen and extruded.
59–130	ad.	♀	17 Apr. 1959	Uterine cyst 180 × 50 mm.
D7–57	ad.	♀	6 Dec. 1957	Abscess in jaw, liver discolored and with abnormal adhesions.[1]
59–85	ad.	♀	25 Mar. 1959	Liver with abnormal adhesions and discoloration.[1]
59–79	juv.	♀	21 Mar. 1959	Hemorrhagic nasal passages.
59–90	ad.	♂	29 Mar. 1959	Cutaneous emphysema.
59–82	juv. (pup)	♀	25 Mar. 1959	Lungs black, pneumonia?
B12–57	s.ad. ?	♀	22 Oct. 1957	Malignant neoplasm of the intestine.[1]
59–48	ad.	♀	4 Mar. 1959	Congenital cystic kidney and edema.[1]

[1] See section on Parasites and Miscellaneous Diseases for a more detailed analysis.

TABLE 58.—*Summary of observations from 83 sea otters found dead at Amchitka Island, Alaska, 1959*

Observation	Number of juveniles	Number of adults
Total animals examined	48	35
Skeletal remains only found [1]	18	14
Field necropsy performed	27	18
Dental malocclusion indicated [2]	24	14
Bone damage to jaw [3]	0	13
Tooth damage (dental attrition): [4]		
None to moderate	44	6
Moderate to severe	0	29
Lesions: [5]		
Hemorrhagic enteritis present	23	11
Stomach parasite (*T. decipiens*) present	2	6
Possible physical injury indicated	12	9
Food in stomach [6]	0	0

[1] Skulls only examined.

[2] In juveniles, malocclusion occurs while the permanent teeth are growing, particularly whe deciduous teeth are pushed out of line. In old adults, postcanine teeth may be worn to the gum line or to the bone.

[3] When teeth of old animals are severely worn, infection of the bone and osteolysis may occur

[4] See Dental Attrition.

[5] See Parasites and Miscellaneous Diseases.

[6] All carcasses showed signs of emaciation. Body weights (particularly for adults) were abnormally low (see Body Measurements).

ibited a degree of malocclusion caused by the growth of the
ermanent postcanine teeth. In the early stages of eruption of the
ermanent teeth, the deciduous teeth are pushed upward, so that
clusion is impaired. When the deciduous teeth are finally lost,
e permanent teeth are still below the level of adjacent teeth
ee Dentition). Adults having poor teeth comprised 78 percent
the total found dead. The attrition of teeth appears to be an-
her result of the reduction of soft-bodied invertebrates. Hard-
helled organisms are probably eaten to a greater degree by this
owded Amchitka population than in less densely populated areas.
nimals having good teeth not only compose a minority (17 per-
nt) of the dead adults on beaches but healthy adults spend less
me on shore (as indicated by animals captured there) during
eriods of storm surf than do emaciated juveniles and old adults.

eather and sea conditions

In the fall of 1959, the U.S. Weather Bureau began to record
eather conditions in the outer Aleutian Islands. Before this time,
such records were available. Thus, during the 21 January to
May 1959 study period I kept a daily record of weather con-
tions. These data demonstrated that the increased mortality
incided with the period of greatest storm activity.

Complete weather records are now available for the years after
60. These data were recorded at Shemya Island, which is 200
iles west of Amchitka, but radio reports of weather at Shemya
ceived while I was on Amchitka indicated that a few hours after
eather conditions were reported at Shemya similar weather
ached Amchitka. The annual cycle of weather conditions in the
ter Aleutians is quite uniform.

The average seasonal mortality observed on Amchitka from
55 through 1963 and the mean monthly wind velocities recorded
60 through 1963 are shown in figure 102. This graph demon-
rates that the period of greatest mortality, when 75 percent of
e annual mortality occurs, coincide annually with the period of
aximum wind velocities in the late-winter, early-spring period.
also shows that the period of least mortality occurs during the
mmer period of minimum wind velocities. In the fall, when the
ason of storms begins, a slight increase in mortality occurs.
ost animals, however, emerge from the summer, early-fall period
good physical condition and the mortality remains low until
ter a period of sustained stormy weather reaches a peak in
arch.

The general coincidence of high mortality and stormy weather

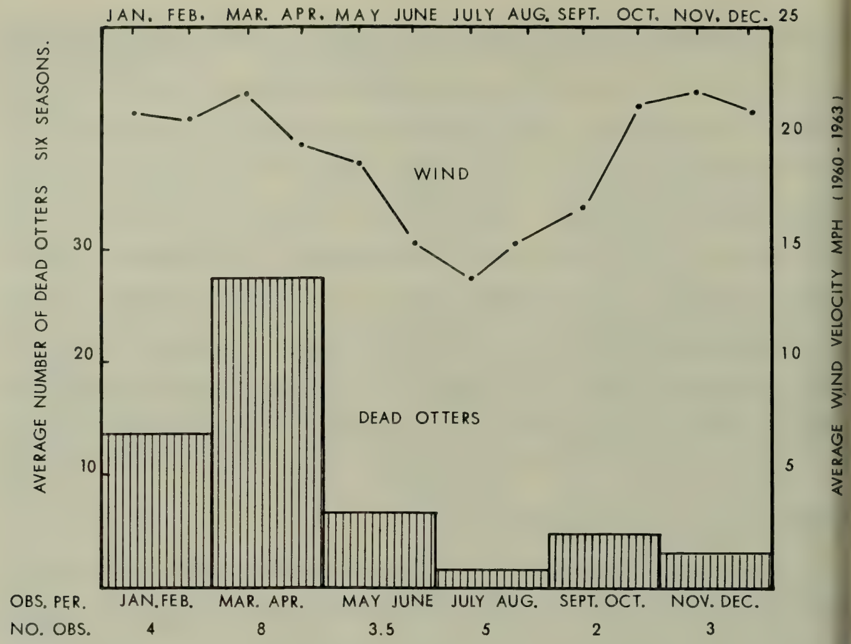


FIGURE 102.—Average seasonal mortality of 311 sea otters found dead on Amchitka beaches 1955–63, and average monthly wind velocities in the outer Aleutian Islands measured by the U. S. Weather Bureau, 1960 through 1963.

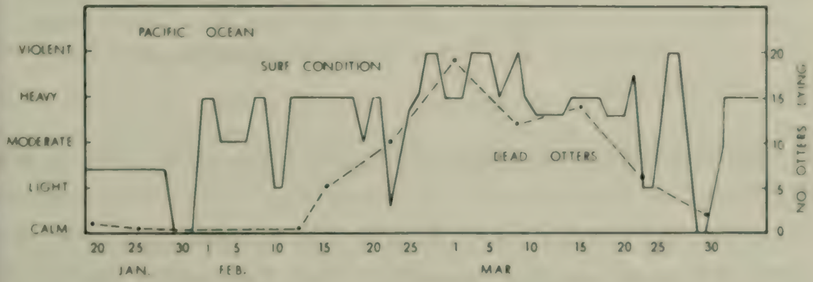
or high velocity winds was quite evident. It was also evident, however, that the wind, as such, was only indirectly responsible for precipitating mortality and that more detailed information concerning environmental stresses was needed. Therefore in 1962, between 19 January and 31 March (70 days), I kept a daily record of surf conditions and sea otter mortality for both the Bering Sea and Pacific Ocean coasts of Amchitka. Five surf conditions were recorded: calm (no surf), light surf, moderate surf, heavy surf, and violent surf.

The vast extent and great depth of the Pacific Ocean as compared to the relatively small and shallow Bering Sea creates conditions responsible for differing surf conditions on the coasts exposed respectively to these two bodies of water.

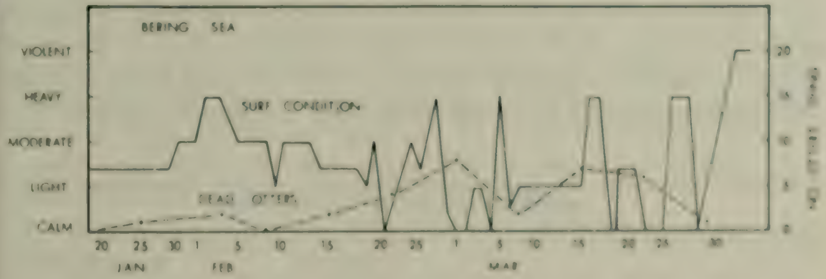
Under the force of storm winds, heavy seas may build up in the Bering Sea, but within a few hours after the passing of a storm the surf may subside and relatively calm or moderate waves may prevail.

In contrast, ground swells in the Pacific Ocean may travel to mchitka's shores well ahead of an atmospheric storm. Then they ay continue to break violently along the exposed coast for many ours after the storm has passed. In addition, waves created by orms that fail to reach Amchitka, may break on the Pacific coast f the island. Heavy or violent wave action along the Pacific ast was recorded on 43 days during the study period, but similar nditions prevailed on only 12 days along the Bering Sea coast igs. 103 and 104).

The data indicate that the amount of mortality that occurred 1962 at Amchitka was related primarily to population size and vailable habitat. Even though the storm wave action along the acific coast was more intense than along the Bering Sea coast, e threshold of stresses sufficient to precipitate mortality was



IGURE 103.—Daily record of surf conditions and of otters found dead on the Pacific Ocean coast of Amchitka from 14 January through 30 April 1962. Partly because ground swells travel long distances in the deep Pacific Ocean, wave activity on that coast is more intense than on the Bering Sea coast (see fig. 104).



IGURE 104.—Daily record of observed surf condition and otters found dead on the Bering Sea coast of Amchitka Island from 19 January through 30 March 1962. Surf conditions are more moderate on the Bering Sea coast than on the Pacific coast because in this relatively shallow sea ground swells do not travel ahead of storms and wave action attenuates soon after the passing of wind storms (see also fig. 103).

exceeded on both coasts. Thus, mortality occurred in proportion to the available habitat and population size rather than in proportion to the intensity of storm wave activity. About two-thirds of the available habitat, population, and mortality were found on the Pacific coast (table 59).

Although the period of heavy surf began in late January, the increasing rate of sea otter mortality did not reach a peak until the end of February (figs. 103 and 104). This is explained by the fact that the otters enter the winter with reserves of body fat and in good general physical condition. During weeks of stormy weather, those animals least able to supply their nutritional needs exhaust their physical reserve. After becoming emaciated and being subjected to continuing environmental stress, they die. Autopsies reveal that almost all animals found dead on beaches show signs of starvation in spite of the fact that their intestinal tract often contained the remains of sea urchins (see Food and Feeding Behavior).

Annual mortality at Amchitka estimated from animals found dead on beaches

Since many of the hauling-out areas on the eastern half of Amchitka were searched carefully and frequently during the period of high mortality, probably most of the dead otters in these limited areas were found. The habitually used hauling grounds constitute less than 10 percent of the shoreline on the eastern half of Amchitka. Other areas could not be searched as carefully as the areas of concentration. On several occasions, dead otters that had been buried in kelp by storm waves or carried from the beach area by eagles were found after having been missed on a previous search. A few dead otters were found well up on offshore rocks that we rarely visited. On the basis of these and other field observations, I have estimated that at least 30 percent of the

TABLE 59.—*Sea otter mortality in relation to population counts and available habitat, eastern half of Amchitka*

	Pacific coast		Bering Sea coast	
	Number	Percent	Number	Percent
Dead otters [1]	70	66	36	34
Otter population [2]	766	71	310	29
Available habitat [3]	45	67	22	33

[1] Count, 19 January to 4 April 1962.

[2] Aerial count, 19 May 1959.

[3] Square miles of water 30 fathoms or less in depth, eastern half of Amchitka. Measured from U.S. Coast and Geodetic Survey Chart 8864.

tters dying along the shores of the eastern half of Amchitka in the eriod of high mortality were not found. A rough estimate of the nnual mortality in 1959 and 1962 on Amchitka is presented below:

	Number of dead otters	
	1959	1962
Carcasses found in winter-spring period	84	106
Estimate of carcasses not found (30%)	25	32
Estimated total mortality this period	109	138
Estimated mortality in remainder of the year (25%)	27	35
Estimated annual mortality on eastern half of Amchitka	136	173
Estimated annual mortality on western half of Amchitka (otter population 30% of eastern half, data from aerial surveys)	41	52
Total estimated annual mortality	177	225

The estimated Amchitka otter population in 1959 was about 080 (see Distribution and Numbers). Thus, the annual mortality ere in at least two seasons was about 9 to 11 percent of the total timated population. If, instead, the direct counts of living and ead otters are used for the eastern half of Amchitka, then the ortality in 1959 was about 8 percent $(\frac{84}{1076})$ 100 and in 1962 out 10 percent $(\frac{106}{1076})$ 100 of the population as observed in 59.

ortality estimates derived from reproductive tracts

The data available from other studies (see Length of stages of productive cycle of female sea otter, by D. G. Chapman, and ield counts of sea otters) makes possible an estimate of the ortality that occurred in the transition from the dependent stage the juvenile stage. Since there are 50 young/100 adult females r year and since the sex ratio among young is 50:50, this plies 25 female young per 100 adult females.

Let the mortality that occurs at the end of the dependent stage T; then

$(1-T)\frac{Y}{2}=J_o$ if females alone are considered

lso

$A=\frac{J_o(.915)^n}{.085}$ from equation (2) (see "Length of stages of reproductive cycles of female sea otter," by D. G. Chapman, p. 243) so that

$$J_o = \frac{.085A}{.766} = .111A$$

$$\therefore (1-T)\frac{Y}{2} = J_o = .111A$$

or

$$(1-T = 2(.111)\frac{A}{Y} = .222/\frac{Y}{A} = \frac{.222}{.42}$$

from (1) (see Chapman, as above)

whence

$$1-T = .53$$

and

$$T = .47$$

Another way of considering the same problem is as follows: Each 25 female young must survive to replace the 8.5 mortality occurring among the mature females

$$\therefore (25)\,(1-T).766 = 8.5$$

or $(1-T)\,(19.2) = 8.5$

or $1-T = .44$ and $T = .56$

Although these are slightly different, they suggest that the transitional mortality from dependent to juvenile stage is about 50 percent. Some of this may occur during the dependent period.

Also, if the mortality among juveniles is higher than 8.5 percent this would mean the transitional mortality is slightly lower. This could also mean that the estimated length of the independent juvenile period is somewhat less than 3 years.

It should be noted that these estimates of 8.5 percent as an annual mortality, 50 percent mortality at the end of the dependent young stage, and a juvenile period of 3 years apply to females. The data do not provide comparable estimates for males.

MORTALITY ON THE SHUMAGIN ISLANDS

The outer Shumagin Islands provide interesting material for comparison with observations from Amchitka. The outer Shumagins, including Nagai and all islands lying east and west of it, are chosen because (1) A population of about 3,000 sea otters is found there, (2) it appears to offer ideal sea otter habitat, and (3) it was accessible for aerial and surface observations.

The outer Shumagins are surrounded by nearly 700 square miles of water less than 30 fathoms deep. The islands are near enough to each other to allow sea otters to move easily from one to another and near enough to other areas along the southeast coast of the Alaska Peninsula to allow population dispersion.

Between 4 and 14 June 1960, the late Tom O'Brien and I camped on Simeonof and Little Koniuji Islands. We circumnavigated Simeonof and made other dory trips to several beaches on Little Koniuji and Herendeen Islands. Also, we walked more than 15 miles on beaches. At least 80 percent of the beachline that we searched was adjacent to favorite sea otter feeding and resting areas.

We searched beaches carefully but were able to find remains of only one adult male sea otter on Simeonof and fragments of one juvenile skeleton on Little Koniuji. Both animals had been dead for several months. Considering that during aerial surveys of these same areas on 10 April 1962 we counted 549 otters, the observed mortality there was low.

Mortality observations in the Shumagin Islands and data presented in the sections on Body Measurements, Food and Feeding Behavior, and Distribution and Numbers, when compared with similar data from Amchitka, indicate that the Shumagin population (4 otters per square mile of habitat) was not overutilizing food resources as was demonstrated for the Amchitka population (19 otters per square mile of habitat) and that winter-spring starvation and accompanying mortality did not occur.

MORTALITY ON THE SANAK ISLANDS

The Sanak Islands include Sanak, Caton, and a number of small islets and rocks. The population density of this area was estimated to be about two otters per square mile of habitat (see Distribution and Numbers).

In 1960, O'Brien and I spent from 20 to 23 June exploring this area. We landed via dory on Caton Island and seven smaller islets Leda, Wanda, Elma, Telemitz, Peterson, and Mary Islets, and Princess Rock). We searched more than 10 miles of beach and found the skeletal remains of only one adult female otter, indicating that little winter-spring mortality had occurred.

Discussion

The analysis of data obtained from two classes of populated sea otter habitat were presented. The criterion of population density was the number of otters per square mile of water less than 30 fathoms deep. It was shown that at Amchitka the population was crowded during the study period, having about 19 otters per square mile. The outer Shumagin Islands and Sanak Islands were not crowded, having respectively about four and two otters per square mile. The estimated annual winter-spring mortality at

Amchitka was 8 to 11 percent of the population (perhaps higher in certain seasons). In the areas of uncrowded population, the annual mortality was much lower. It was not calculated because too few dead otters were found.

The natural forces which control the magnitude of the sea otter population at Amchitka were a limited food supply and climate. From his observations on Amchitka, Rausch (1953) suspected that much of the annual mortality was the result of "A population that exceeded the carrying capacity of the habitat." The applicable generalization was aptly stated by Lack (1954):

> climatic factors can exert an important modifying influence in the control of animal numbers. Thus, although one may speak loosely of mortality due to climate, the actual cause of death is often starvation, which can be density-dependent.

The data presented here and in the sections on Food and Feeding Behavior and Distribution and Numbers, I believe, support Lack's statement.

The following points are the evidence that lead to the conclusion stated above:

1. The food habits studies of otters at Amchitka indicated that healthy adults, having ample body fat in the late-winter, early-spring period, fed to a large extent on fish and octopus. Sea otters at Amchitka were limited in their search for food to a relatively narrow belt of water surrounding the island where water depths do not exceed 30 fathoms (see Diving). Observations at Amchitka indicated that populations of bottom-inhabiting food species were reduced (see Food and Feeding Behavior).

2. Observations indicated that large juveniles when deserted by mothers were unable to obtain a sufficient quantity of high-calorie food species. Apparently they lacked both the skill and strength to capture and hold most fish and octopus. This may be true also of aging adults.

3. Both of these age groups were forced to obtain what nourishment they could from depleted populations of sedentary and often hard-shelled and low-calorie invertebrates. Because of the hard shells of these organisms the teeth of adult otters in the Amchitka population showed greater attrition than did those of animals from less crowded populations. The teeth of old adults were often worn to the gumline. Evidence of bone infection, which often resulted when tooth attrition was severe, was found in 72 percent of a sample of dead adults. Juveniles in the process of replacing deciduous teeth were unable to eat a sufficient quantity of the available hard-shelled organisms.

4. Both the aging animals and juveniles, forced to utilize poor uality foods, were further hindered in feeding activities by sus-ained periods of rough seas. Aging adults, and juveniles deserted y mothers, after exhausting accumulated summer and fall re-erves of body fat, developed enteritis which is typical of that ound in other species of animals under conditions of starvation nd stress (see Parasites and Miscellaneous Diseases).

5. Adult otters at Amchitka weighed less than otters from less rowded populations (see Body Measurements).

6. When weakened animals exhibiting symptoms of enteritis black feces) were captured and placed in a pool of clean water here they were furnished adequate food, some of them regained ealth. After they were introduced to a diet of fish, all of these aptives refused to eat sea urchins and most hard-shelled mollusks. he gastrointestinal tract of similar animals that died on beaches ither were empty, or contained only hard-shelled organisms.

ARASITES AND MISCELLANEOUS DISEASES

Both in the wild and in captivity sea otters are afflicted by a ariety of pathological conditions. Systematic, long-term studies f pathology were not undertaken, but animals found dead or ying on beaches were examined (Rausch and Locker, 1951; ausch, 1953) and observations of captives were recorded (Kirk-atrick, et al., 1955; Kenyon, Yunker, and Newell, 1965). Jellison nd Neiland (1965, p. 8–9) list the parasites of sea otters. In the ollowing sections these studies are reviewed briefly and additional bservations are presented.

Most sea otters found dead on Amchitka Island displayed ter-inal symptoms of enteritis. Other pathological conditions, such s neoplastic and degenerative changes in the liver, ulceration of he jaws and alveoli of the teeth, and infections of the paws also ccurred.

nternal (helminth) parasites

More than 30 sea otters found dead or in moribund condition on mchitka beaches in 1949, 1951, and 1952 were studied by Rausch Rausch and Locker, 1951; Rausch, 1953). The helminths recorded rom these were: (Cestoda) *Pyramicocephalus phocarum* (Fabri-ius, 1780); (Trematoda) *Orthosplanchnus fraterculus* Odhner, 905, *Phocitrema fusiforme* Goto and Ozaki, 1930, *Pricetrema alophi* (Price, 1932), *Microphallus pirum* (Afanas'ev, 1941); Nematoda) *Terranova (Porrocaecum) decipiens* (Krabbe, 1873); Acanthocephala) *Corynosoma strumosum* (Rudolphi, 1802).

R. L. Rausch (letter, 15 Sept. 1967) states:

> More recently, *Corynosoma macrosomum* Neiland, 1962, has been described from a sea otter from Prince William Sound, and a single specimen evidently representing this species had been collected earlier from the same host from Simeonof Island (see Neiland, 1962). Cestodes collected by K. W. Kenyon from sea otters from Amchitka Island have been identified provisionally as *Diplogonoporus tetrapterus* (von Siebold, 1848) (Rausch, 1964); this species also was recorded from a sea otter from Prince William Sound.

In general, these helminths probably affect the host little, if at all (Rausch, 1953). However, two species, *Microphallus pirum* and *Terranova decipiens,* were considered to be pathogenic. The cuticular spines of the former evidently cause mechanical injury to the intestinal mucosa, and, when the trematodes are abundant, severe enteritis may result. Immature specimens of *T. decipiens* frequently penetrate the intestinal wall and enter the body cavity, where other organs may be invaded. Peritonitis following such perforations may result in the death of the host.

During the 1955–63 study period, I made gross examinations of about 50 otters believed to have been in good health when killed at Amchitka. Although both *T. decipiens* and *M. pirum* were found, there were no gross lesions in the infested animals. In November of 1957, Dr. Kenneth L. Binkley examined seven adult otters at Amchitka, only one of which appeared to be in "poor" condition when captured. Only the ill animal was infested with an appreciable number of *T. decipiens* (65 worms) and *M. pirum* (many worms), but there was no sure indication that this animal's poor condition was a result of parasite infestation. Problems encountered with *T. decipiens* are discussed under "In Captivity."

In 1959 the stomachs of otters found dead on beaches were examined when possible. Among 27 juveniles, 2 contained *T. decipiens* and among 14 adults, 5 were infested. In none of the animals examined were helminths found in the coelom and no instance of perforation caused by helminths was noted. The animals, in most cases, had been dead for several days before they were examined. Peritonitis caused by perforation of the gastrointestinal tract would probably have been detected. Examination of sample areas of the small intestine revealed moderate to light infestation in some animals, but for *M. pirum* diagnosis was considered unsatisfactory because of decomposition. In addition, this parasite inhabits crypts in the wall of the small intestine and is not easily detected in gross examination.

K. A. Neiland (letter, 9 July 1962) examined the intestinal tracts of 8 adult sea otters chosen at random from 150 animals that were shot in the spring of 1962 at Amchitka. In these he found a total

271 *Corynosoma* sp. Infestation ranged from 1 to 98 individuals. *decipiens*, totaling 40 individuals, occurred in 5 of the tracts l infestation ranged from 1 to 18.

A subadult female sea otter was found dead at Patten Bay, ntague Island, by Theron Smith on 23 April 1962. The animal s estimated to have been dead for 2 or 3 days when it was eived for study by Dr. Francis H. Fay. Because death ap- rently resulted from helminth infestation, his study of this mal (No. 27830) is quoted from his letter of 7 August 1962.

> rematoda: *Orthosplanchnus fraterculus.* Abundant in gall bladder bile ts. Extreme fibrosis and near-occlusion of bile ducts was noted in several as of the liver.
>
> *icrophallus pirum.* Abundant in small intestine.
>
> estoda: *Diplogonoporus tetrapterus.* Several large pseudophyllidean odes with double genital pores were present in the small intestine. A few ller cestodes, closely associated with these, were also present and are eved to be aberrant individuals of the same species.
>
> ematoda: *Terranova decipiens.* Massive infection, mainly of larval worms. se had perforated the stomach in one locality and the duodenum in two. y were free in the abdominal cavity, together with *M. pirum* and two ies of *Corynosoma.* In the abdominal cavity there was about 1,000 ml. loody fluid with some remnants of food that evidently had oozed out of the stine by way of the perforations. A group of nematodes was attached he greater omentum, and several other groups had penetrated the spleen liver. Extreme inflammation was evident in these sites even in the then mposed tissues. All mesenteries in both the abdominal and pleural cavities granular and inflamed. Adhesions were abundant.
>
> canthocephala: *Corynosoma* sp. At least two species of *Corynosoma* were dant in the small intestine." (These were later identified by K. Neiland *. strumosum* and *C. macrosomum.*)
>
> was apparent from the gross pathology that this animal had died as a lt of its dense, infiltrating parasite population, but it was not possible to le on which of the two most pathogenic organisms (*M. pirum* and *T. piens*) was primarily responsible for causing death.

ernal parasites

now (1910, p. 278) examined many sea otters and said of n "Sea-otters are particularly cleanly animals; I have never nd a parasite of any description on them."

. H. Fay (letter, 6 April 1964) said:

> e have no records of Anoplura on sea otters, but on the other hand, the ber of specimens examined is not great. Both Bob [Rausch] and I feel Barabash Nikiforov's record of two specimens of *Proechinophthirus us* (= *Echinophthirus fluctus*) on sea otters probably was fortuitous. Ap- ntly this is a common ectoparasite of *Callorhinus* and *Eumetopias* living e same area with the otters, and it is not inconceivable that a few would ionally be picked up by the otters. If it were a common or even uncom-

mon parasite of sea otters, you surely would have noticed it, especially in captive animals.

I have examined many sea otters and found no external parasites other than nasal mites (Halarachnidae). Although these are technically ectoparasites, they are found within the nasal passages. As pointed out previously (Kenyon, Yunker, and Newell, 1965), infestation of the sea otter with *Halarachne miroungae* is probably fortuitous. The only massively infected animal (over 3,000 mites) was a captive that was held under abnormal conditions in a freshwater pool. Infestation in the wild appears to be insignificant.

Enteritis

The following discussion presents observations obtained at Amchitka Island and information contributed by M. C. Keyes, D.V.M., Bureau of Commercial Fisheries.

Enteritis is frequently observed as the terminal symptom at death in sea otters at Amchitka. It is similar to the entero toxemia found in the fur seal, harbor seal, and certain domestic animals. A *Clostridium* organism has been isolated and identified from a fur seal. Keyes (1963) uses the name necrohemorrhagic enteritis. The symptoms observed in the sea otter are quite similar to those observed in lambs and other mammals.

Symptoms exhibited by sea otters found on Amchitka beaches are listed:

1. The animal may be unable to stand or walk.
2. It may appear semicomatose or very lethargic and fearless
3. It often exhibits hiccup-like convulsions.
4. The vibrissae may be extended rigidly forward.
5. The necropsy reveals intestinal lesions of variable extent.

Young animals may die while lesions are small, affecting 3 to 4 inches of the small intestine. The intestine is inflamed, muscle tone is lost, and affected areas become blackish or greenish blac in color. In adult animals, long sections of the small intestine show this condition at death. The colon has not been specifically observe to show the extensive lesions found in the small intestine.

The small intestine and colon often contain the remains of abou a dozen small sea urchins. Black tarry feces may or may not b voided before death. In young animals particularly, the progres of enteritis to death may be rapid.

6. Death may occur before the typical black fecal matter i voided. The black condition of the feces is called melena (a com bination of the iron found in hemoglobin and hydrogen sulfide to

gether produce iron sulfide, the putrafactive changes in the intestine produce the H_2S).

7. I have examined the stomachs of more than 200 otters that showed symptoms of enteritis at death. None has contained food. The stomach may contain from 10 to 50 ml. of liquid which may be pinkish, reddish brown, or yellowish. The mucosa may show inflammation.

8. Weight loss, probably caused by dehydration and starvation, characteristically accompanies enteritis. A captive juvenile male (59–159), that died showing symptoms of enteritis, lost 26 percent of its body weight in 3 days.

It appears probable that a *Clostridium* organism is present in all animals and that it becomes active when the animal is subjected to stress, such as starvation or nervous tension. Unsatisfactory conditions in captivity, such as lack of water, may cause such nervous tension. In captivity, I have observed that animals given access to an abundant supply of clear water and abundant food have not been subjected to sufficient stress to develop enteritis. As pointed out elsewhere, animals which show symptoms of enteritis when captured may recover in captivity when given abundant food and water. Stress may be caused in captivity if the fur becomes dirty and the animal is chilled. Extreme anxiety accompanies chilling, a large intake of food may occur but unless the fur condition can be improved the animal experiences stress; enteritis usually develops, and is followed in a few hours by death. In the wild, lack of nourishing food and accompanying rough, stormy seas appear to cause stress that results in enteritis and terminates in death.

Additional laboratory examination of specimen material taken from sick or dying sea otters is needed before we can attain a proper understanding of the relationship between enteritis and the trematode *Microphallus pyrum*, and the bacterium, *Clostridium*, in the sea otter.

Infection and liver degeneration

Dr. Dean Jensen, College of Veterinary Medicine, Colorado State University, kindly made a study of pathological tissues obtained from animals found dead or dying at Amchitka.

An adult female (D7–57), having well-worn teeth, weighed 56 lb. (25.4 kg.) when captured alive on 1 December 1957. Her weight at death, 6 December 1957, was 47 lb. (19 kg.). This animal lacked energy and ate sparingly during the period of captivity.

Fur preening was also inadequate. The animal, in general, appeared to be in poor condition.

Necropsy.—The liver appeared fibrous and spotted with various shades of brown and reddish inflammation. In three places the omentum adhered abnormally to the liver and there were numerous abnormal adhesions between the lobes of the liver. Yellowish scar tissue surrounded the areas of adhesion. The spleen appeared abnormal, exhibiting a somewhat opaque whitish scum over one side. Linear indentations crisscrossed this surface. Specimens were preserved in AFA solution, then transferred to 70 percent alcohol. A large abscess surrounded the root of the lower right canine tooth. Considerable osteolysis of the jaw had occurred around the root of the tooth forming a hole in the bone which measured 10 × 8 × 7 mm. Other organs appeared normal to gross examination.

Dr. Jensen's analysis:

> Hemopoietic system: Histopathology: Spleen: Parenchyma is diminished while capsule and trabeculae are abundant. These changes indicate atrophy from unknown cause. The periphery of some central arterioles contain a homogenous acidiphilic substance which may be amyloid [starch-like].
>
> Liver: Many lobules show fatty metamorphosis in central zones. This change is not uniform.

Although Dr. Jensen gave no diagnosis in this case, it was apparent that this animal was moribund. It would appear that toxins from the infected jaw may have caused the fatty degeneration and sclerosis of the liver.

The results of a necropsy of another otter was similar but no localized infection was found: KWK 59–85, adult female, weight 37½ lb. (17 kg.), collected 27 March 1959, found dead well above high-tide line in sleeping position. The liver appeared swollen and fibrous with considerable yellowish discoloration, scar tissue, and abnormal adhesions to the diaphragm and intestines. Peripheral blood vessels of the liver and intestines were turgid. The otter had bled from the rectum before death.

Malignancy

On 22 October 1957, a young adult female sea otter (B–12–57), weighing 42 lb. (19 kg.), was found dead on a rock well above high-tide line at Amchitka. A necropsy revealed abnormal tissue growth in the viscera and a quantity of dark, apparently bloody fluid in the coelom. Externally in other respects the animal appeared normal.

Dr. D. V. Brown, then Associate Professor of Pathology, Uni-ersity of Washington and Chief, Laboratory Service, Veterans dministration Hospital, Seattle, examined the specimen material d gave the following information:

> *Gross examination:* Specimen as received, fixed in formalin, consists of a leen, stomach, duodenum and what appears to be the greater portion of the all intestine with its mesentery. Tissue preservation appears to be good.
>
> The spleen is firm and rubbery with a roughened, granular capsule which gray-blue in color. It weighs approximately 60 g. and measures 14.0 × × 2.0 cm. in its greatest dimensions. On section it is homogeneous roughout with no focal areas of gross change.
>
> The stomach appears to have a wall of normal thickness. Within the lumen ere is a little green pulpy material but no suggestion of old or recent eding. The mucosa seems well preserved. The pyloris and duodenum appear rmal.
>
> Throughout the small intestine the bowel wall and the adjacent mesentery irregularly thickened with firm, gray tissue which appears neoplastic ew and abnormal growth]. The bulk of this is in the distal end of the bowel parently near the cecum. The gray tumorlike tissue infiltrates and thickens bowel wall in some areas and extends out into the mesentery which is also ckened and gray. Toward the distal end, the mesentery contains a large rsely nodular mass (8.0 × 6.0 × 4.0 cm.) which on section is solid and ay.
>
> Small solid gray masses scattered through the mesentery are apparently ier involved lymph nodes.
>
> Sections for microscopic study are taken as follows: Spleen, stomach, wel wall, lymph nodes and mesenteric mass.
>
> Microscopic: Sections of spleen are quite well preserved. No abnormalities recognized.
>
> A portion of pancreas is included and it too does not seem remarkable.
>
> Sections of enlarged lymph nodes show focal areas of apparent neoplastic asion. The tumor here is partially replacing the nodal substance and is ilar to that described below.

M. C. Keyes, D.V.M., who examined Dr. Brown's histological eparations, considers that the condition described may be diagsed as leiomyoma or a leiomyosarcoma.

w infections

Several otters with infected forepaws were captured on Amitka beaches. It appeared that puncture wounds, perhaps made sea urchin spines, caused the infections. In captivity, infections veloped in all extremities. In at least three cases infections curred in puncture wounds or cuts originating on sharp ends hardware cloth, used on the enclosure. Repeated doses of antitics successfully cured these infections in some animals.

Blindness

Otherwise healthy sea otters blind in one eye were occasionally seen at Amchitka. No wild otter blind in both eyes was observed. The cornea of the left eye of a yearling otter (Susie) was punctured near the center by a tiny "pinhole" when she was captured at Amchitka in 1955. Within weeks the eye became cloudy and eventually completely blind. About 2 years before her death in 1961 the right eye also became cloudy (presumably affected by the other blind eye) and total blindness resulted. Because she had learned the topography of her enclosure well before losing her sight, she appeared to experience no difficulty in finding her food and her way about her quarters.

Intussusception

Blocking of the small intestine by the intestine "swallowing" itself occurred in three captive otters. These animals were held in unsatisfactory cages without sufficient water for immersion. The animals appeared to experience emotional stress, as evidenced by frequent vocalization for one or more days before death occurred.

Predation

No information exists to indicate that predation by animals (other than man) on the sea otter is an important factor in its population dynamics. Available information on predation is presented below:

SHARKS

It is beyond question that some sea otters are killed by sharks. Snow (1910, p. 278) states:

> Wounded otters I have taken on a few occasions, but they had been bitten by sharks, as I know from finding several of the sharks' teeth broken off in wounds.

Orr (1959) discovered the broken tooth of a great white shark *(Carcharadon carcharias)* in the lacerated body of a sea otter found dead at Pebble Beach, Calif. He considered that one other otter he examined definitely died from shark wounds and that several others found dead and bearing lacerations may have died as a result of shark attacks. That skin divers may have inflicted fatal wounds with spears, although a possibility, must be considered an opinion to be carefully weighed, since no proof that this ccurred is available. Limbaugh (*in* Gilbert, 1963) says that "white harks may be threatening" the small sea otter population on the entral California coast. The degree to which man or sharks kill ea otters along the California coast still appears to be an unesolved question. In Alaska no deaths attributable to sharks are ecorded.

ILLER WHALE *Orcinus orca*

Presumably the killer whale may eat sea otters. I have watched iller whales and otters in the same area and have not seen a hale attack an otter. Nikolaev (1965b, p. 231), however, saw a iller whale catch one sea otter.

On 1 March 1959, near South Bight on the Pacific shore of mchitka, I watched from the cliff top as five killer whales cruised bout outlying reefs. As the whales approached the reefs a harbor eal left the water and climbed onto the rocks. The whales cruised lose to the reefs, then proceeded eastward parallel to the shore nd into an area where four sea otters were feeding. One otter as eating on the surface when the whales approached and passed nly a few feet beneath it. This otter appeared to sense the presnce of the whales. It stopped eating and remained motionless hile they passed. Otherwise, the otters seemed undisturbed by the hales and the whales exhibited no discernible interest in the tters.

On 9 April 1959, R. D. Jones and I observed killer whales and tters in the same general area off Kirilof Point on the Bering Sea hore of Amchitka. On several occasions between 1345 and 1645 e spent nearly an hour watching two groups of killer whales, ne of 9 and the other of 18. They moved parallel to the shore and emained from a quarter to one-half mile from land. Several indiiduals raised the head and anterior quarter of the body above the urface as if to search the surface visually. Sea otters that were od diving in their vicinity ceased this activity and lay still on e surface or moved slowly toward shore on the surface. We did t see any behavior by the whales which indicated to us that a a otter was attacked.

A further observation by Jones (letter, 9 July 1961) is similar. t Rat Island he saw six killer whales which remained for some me "from 25 to 100 yards off" shore and in the vicinity of "a rge pod (over 200) sea otters." The sea otters exhibited "no arm" and the whales did not attack them.

Although Barabash-Nikiforov (1947) gives no observation of a killer whale attack on a sea otter, he lists them as an enemy and presumed "that killer whales terrorize sea otters."

BALD EAGLE *Haliaeetus leucocephalus*

The sea otter population at Amchitka progressed from near extinction at the turn of the century to maximum size in about 40 years. At the same time a large population of eagles occupied Amchitka.

From many months of field observations by a number of observers there is only one authentic observation of an eagle attacking a living sea otter. This occurred on 3 June 1961 at Barr House Cove on Amchitka Island. In a letter of 17 October 1961, R. D. Jones reported what he and Vernon D. Berns observed:

> We were on the beach of the cove watching the eagles with binoculars . . . [an eagle] launched and flew . . . to sea losing altitude rapidly and disappearing behind the island. The eagle quickly returned directly to the island . . . carrying a large bulky object . . . [which it] carried . . . to the nest and upon our approach took wing. It was not necessary for us to climb the pinnacle to know there was a sea otter pup in [the nest] for the screaming of the pup was all too clear. We did climb it, however, and observed three eagle nestlings and the still living pup.

Sea otter remains frequently occur in eagle nests (Krog, 1953; Kenyon, 1961, 1964) where the two species occur together. That certain individual eagles may develop a taste for sea otters, while others do not, is indicated by the failure of Murie (1959) and D. C. Hopper (*in* Jones, R. D., unpublished report of 1 January to 31 August 1953) to find sea otter remains in eagle nests they investigated on islands where sea otters were numerous. I obtained many observations at Amchitka of eagles feeding on carcasses of sea otters that died of natural causes and saw them carry parts of these carcasses away in their claws. The otter remains frequently seen in eagle nests undoubtedly include many that were obtained by scavenging rather than predation.

One observation quoted from my field notes is typical of many:

> St. Makarius Bay, Amchitka Island, 2 April 1959, 0900. At water's edge an adult eagle was finishing the remains of a large fish (ca. 30 in. (0.75 m.) long, washed ashore dead) while four other eagles (all in subadult plumage) rested on the beach and bluff. In the midst of this group, a young male sea otter—just awakened from the night's sleep—squirmed about on the dry grass (est. wt.=25 lb. (11.3 kg.)). Obviously the eagles were paying no attention to the sea otter and the otter was certainly not alarmed at the eagles' presence.

In places where one or more eagles were near, I frequently saw helpless young sea otters left floating on the surface while the nothers dived for food. Although the young otters would have een easy prey, I never saw an eagle attempt to take one.

My observations indicate that predation by the Bald Eagle on he sea otter is unimportant.

Environmental Pollution

Fur cleanliness is essential to the sea otter's survival. If the fur ecomes soiled by foreign matter it loses its water-repellent charac- eristics, the insulating blanket of air among the dense fur fibers s lost, the animal is chilled, and soon dies.

Pollution of waters by oil and other by-products of industrial levelopment preclude the possibility that the sea otter can today eoccupy all of its former habitat. San Francisco Bay, in early ears, "abounded in otters" (Ogden, 1941). Pollution by oil and ther wastes today would certainly preclude their survival there r in the vicinity of the Golden Gate. Periodically the outer coast f Washington State, which once supported a thriving sea otter opulation, is polluted by oil from the many ships which navigate he Strait of Juan de Fuca. That a permanent population of sea tters could today survive in this otherwise ideal coastal habitat s questionable.

Not only is the sea otter affected directly by habitat pollution ut where pollution is acute, as in San Francisco Bay, food organ- sms are also affected and reduced or eliminated.

Poaching

Poaching or illegal killing of sea otters in Alaska is not known o be a serious problem. Holger Larsen of the U.S. Fish and Wild- ife Service said "it has been known that illegal furs have moved hrough Valdez since 1938" (Seattle Times, 2 February 1956). he only arrests in recent years, however, were of a Fairbanks fur ealer in 1944 for the possession of a sea otter and of two men in n Anchorage hotel on 1 February 1956 who had in their posses- ion eight sea otter pelts. Ray Woolford of the U.S. Fish and Vildlife Service said (letter of 18 March 1964):

> robably more sea otters are accidentally shot by inexperienced seal hunters han are deliberately killed with the intent to commercialize on fur. I think the ccidental kills by seal hunters and others traveling coastal waters have a otential for increasing so long as seals remain unprotected and a bounty is aid on them.

Various reports of poaching by foreign nationals in the outer Aleutian Islands are not confirmed.

The problem of illegal killing of sea otters may be of more importance in California. Captain Howard Shelby of the California Department of Fish and Game reported that in one period (late 1957 and early 1958) in the Monterey area alone 18 dead otters were found. "Some had a hole clear through them, either spear or bullet wound." He said further that "it's my opinion that there are people and there are groups of people who do definitely shoot this animal. Then there are quite a group that target practice at anything." (California Senate, 1963)

Summary

1. Few sea otters were found dead on Amchitka beaches in the period 1938–40. The first report of significant natural mortality was made in the spring of 1948 when "more than 100" otters were found dead on beaches. Since the late 1940's significant late-winter, early-spring mortality was observed when biologists visited Amchitka. During five study periods from 1956 to 1963, data were obtained from 311 otters found dead or dying on beaches of the eastern half of Amchitka Island.

2. The greatest number of otters usually died in the month of March but considerable mortality also occurred in February, April, and May. In this late-winter, early-spring period about three-quarters of all annual mortality occurred.

3. Approximately 70 percent of the late-winter, early-spring mortality occurred among juveniles deserted by mothers. The other 30 percent of dead animals were predominantly adults showing signs of age.

4. During the period of stress caused by storms, mothers deserted their large juveniles at an earlier age than they did at other seasons. They appeared to do this because it was difficult for a mother to obtain sufficient food to satisfy both herself and the large juvenile. Few very small pups were found dead even though they were present in the population at all seasons.

5. Mortality was usually greater among males than among females. Among juveniles this disparity was greater than among adults. Males in captivity were found to be less hardy than females.

6. Vigorous adults were able to obtain adequate nourishment from high-calorie foods, such as fish and octopus. These organisms were seldom obtained by juveniles and aged animals.

7. A high percentage of juveniles and aged animals found

ad on beaches exhibited malocclusion of the postcanine teeth.
juveniles this condition resulted when deciduous teeth were
ing replaced by permanent teeth. In adults malocclusion resulted
om severe tooth attrition which may have been caused by chew-
g hard-shelled invertebrates.

8. Prolonged storm conditions precipitated mortality but the
nount of mortality was found, in 1962, to be related to the avail-
le feeding habitat and population density.

9. The relative intensity of storm wave action was greater on
e Pacific Ocean coast than on the Bering Sea coast, but the mor-
lity on each coast was proportional to population density and not
relative intensity of storm conditions, indicating that the thres-
ld of conditions causing mortality was passed on both coasts.

10. The annual mortality of the Amchitka population was esti-
ated in 1959 and 1962 to be about 8 to 11 percent. Two methods
estimating mortality gave similar results.

11. In the Shumagin and Sanak Islands areas, where the sea
ter population was about four and two otters per square mile of
ater less than 30 fathoms deep, respectively, no evidence was
und to indicate unusual mortality in the late-winter and early-
ring storm periods.

12. The Amchitka population was about 19 otters per square
ile of water less than 30 fathoms deep and had overexploited
rtain food resources. Because of this fact, the population was
stricted by relatively high mortality which resulted primarily
om malnutrition and was precipitated by environmental stresses
ring late-winter, early-spring storms.

13. Sea otters are infested by a variety of internal parasites
t these rarely appear to be the direct cause of significant mor-
lity. External parasites are limited to fortuitous infestations
nasal mites. Such infestation is unusual in wild otters.

14. The most frequently observed condition at death was
aciation accompanied by hemorrhagic enteritis. Chronic disease
nditions and bodily injuries were observed.

15. Sharks, the Bald Eagle, and killer whale are known to kill
a otters. Predation, however, is probably an insignificant source
mortality.

16. Environmental pollution in areas now heavily utilized by
n will probably prevent the sea otter from reoccupying all of
former range.

17. No evidence is available to indicate significant illegal kill-
g by man of sea otters in Alaska. In California, however, illegal
ling by man may, today, hinder the increase of the sea otter
pulation.

IN CAPTIVITY

The sea otter is highly adaptable to life in captivity. When its environmental and food needs are met, it is hardy and appears contented in air temperatures from about 15° to 85° F. By nature it is placid and tames quickly. Some individuals accept food from the hand within a few minutes of capture.

Certain features of the captive environment are, however, extremely critical. The sea otter in captivity must have free access to an abundant supply of clean water. It also requires access to clean, dry areas but, in warm weather, it may spend entire days without leaving the water. Free air circulation is also a requirement. Cleanliness of the fur is essential; if the fur becomes soiled, the air blanket trapped among its fibers is destroyed, the skin then becomes wet, and death from chilling soon follows.

Its food requirement of about 20 to 25 percent of its body weight per day must be fulfilled. It readily eats a variety of fish, mollusks, and crustaceans but will remain in good health on a monotonous diet.

If clean water is withdrawn for even a short period, as during travel on ship or aircraft, death may occur soon after the animals are allowed to enter cold water. When water is not available, captives are emotionally upset and extremely sensitive to air temperatures. In dry cages, air temperature near 50° F. has caused distress, and animals exposed for a few hours to temperatures near 70° F. died.

The information gained from holding many captive otters is reviewed below.

Capture

Most sea otters taken alive are captured in nets. The historical record indicates that in early times, also, nets were employed. Steller (*in* Jordan, 1898–1899, Vol. 3, p. 214) states that anchored nets were spread on the water's surface and that carved wooden otters were used to attract otters into them. Of the captives he says:

> When they are caught in the nets they are so frantic that in their despair

they bite off their front feet; but if a male and a female are caught together they both lacerate their skins terribly and knock out their eyes.

After capturing more than 200 sea otters in dip nets, I have concluded that Steller's description is an exaggeration. That a netted otter is frantic is true. One particularly nervous female did chew off the first joint of one hind toe and tore at the skin of her belly with her teeth, but such behavior is unusual. Usually the netted otter bit the netting and with the help of its forepaws attempted to break the strands or attempted to push the strands away from its face and body with the forepaws.

On several occasions a mother and young were taken in the same net. A large juvenile bit its mother repeatedly on the head and body in its frantic efforts to escape. These two animals were quickly separated, tagged, and when released the juvenile joined ts mother and the two swam away together. After being placed in a small carrying cage, otters usually rested quietly.

Soviet biologists working in the Kuril and Komandorskie Islands used landing nets and "boundary nets" to capture otters (Barabash-Nikiforov, 1947; Voronov, 1960).

Officials of the Alaska Department of Game successfully capured otters in Prince William Sound in a nylon salmon gillnet set rom a boat (J. Vania, personal communication).

At Amchitka, otters haul out at certain times to sleep on beaches. With practice and care we caught these animals in a salmon landing net (fig. 82).

We captured otters most easily during late winter and spring. n this period, prolonged storms caused juveniles and older animals o weaken and come ashore. Healthy young adults were also taken, but less often. In summer, fall, and early winter, when storm periods were of shorter duration, few otters came ashore. In ummer months, when calm weather prevailed, otters were paricularly difficult to net on beaches. In summer, however, numbers id haul out at night to sleep on kelp-covered rocks close to the water. At this season, we found the best opportunities for netting tters when low tide coincided with dawn.

The reasons that otters may be netted on shore with relative ase are: (1) They often sleep soundly, (2) their sight and hearing re such that unless a moving figure appears above the horizon or nnecessary noises are made, the animals are often unaware of he hunter's presence, (3) they may be easily outrun by a man nless at the water's edge, and (4) they are placid and do not ecome alarmed easily.

In general, we found that otters may be classified in order of the ease with which they may be captured on shore as (most difficult first): (1) mothers with young, (2) adult females, (3) juveniles, and (4) adult males. Mothers with young were difficult to net because (1) they were alert, slept lightly, and retreated to the water at any hint of danger, and (2) they came ashore in places that were least accessible to enemies.

Because the sea otter has an acute sense of smell, animals of all age and sex classes must be approached upwind. Among rocks and near cliffs, eddy currents may carry enough scent in an upwind direction to alarm and stampede otters before they can be captured.

Captured otters were removed from the landing net either by placing a small carrying cage at its mouth (fig. 105), or by lifting

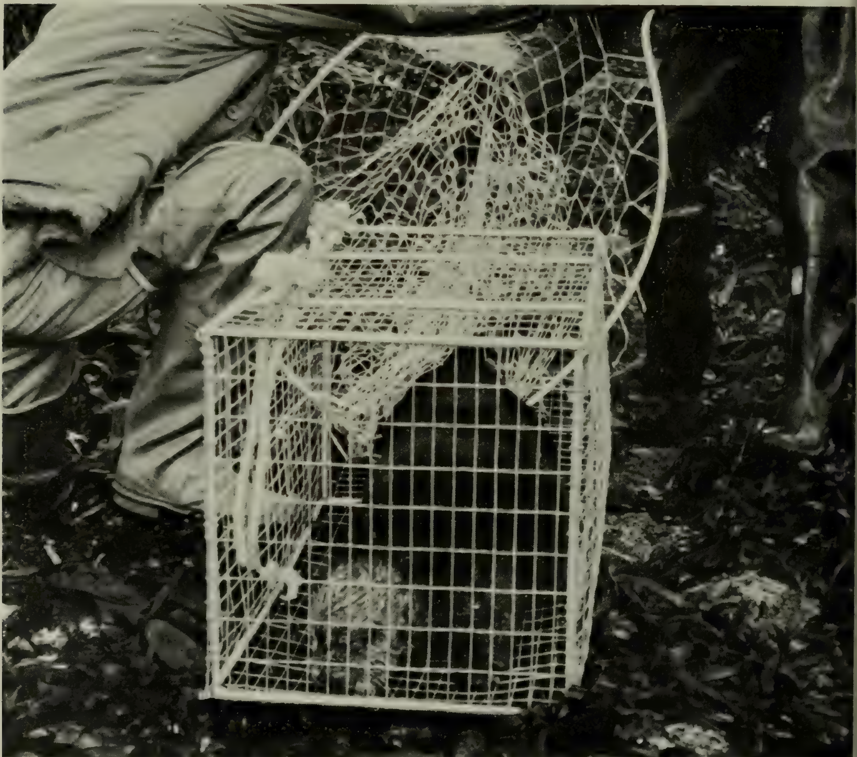
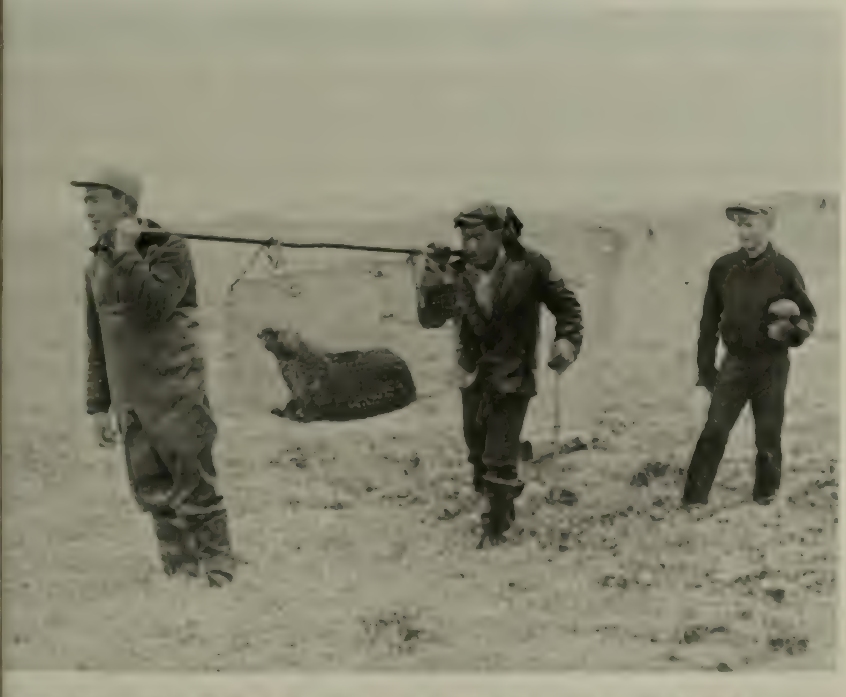


FIGURE 105.—After a sea otter was netted, a carrying cage was placed horizontally on the rocks and the otter was allowed to move from the net into the cage. After the animal entered, the cage was turned upright and the lid was fastened. The cage was then strapped to a packboard or suspended from a pole for transport to a truck or boat. (KWK 55–8–10)

he animal by its hind legs into a vertically placed cage. An otter eld off the ground by its hind legs is unable to bend its body far nough to bite its captor. The caged otter (fig. 106) was then arried to a boat or to the nearest road.

Environmental Needs of Captives

From 1932 to 1937 Soviet biologists experimentally held captive ea otters (Barabash-Nikiforov, 1947). Animals were eventually eld successfully in cages built at the edge of a bay where tidal ater was used to flush and clean the enclosures (Reshetkin and hidlovskaya, 1947). The details of this work were unknown to s until 1962. Even so, all coastal areas at Amchitka, where our ork was done, were exposed to storm waves, so we could not se enclosures placed directly in sea water. After considerable exerimentation, a satisfactory field holding facility was constructed n land.



IGURE 106.—This 65-lb. male otter was carried for over a mile in this manner. After an initial frantic struggle when netted, it settled down and rode quite calmly in the cage. (KWK 56-3-40)

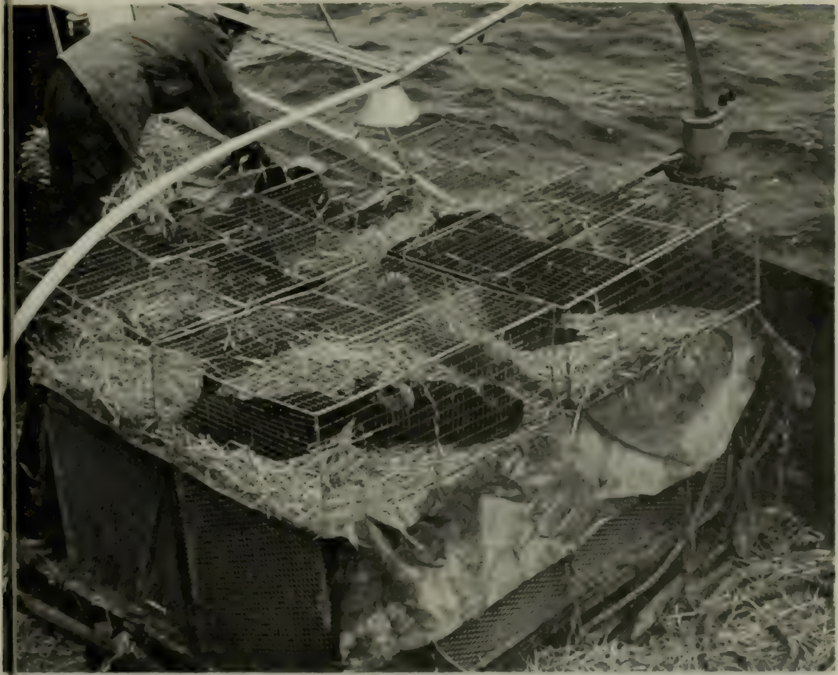
If sea otters are to survive in captivity, they should, within about 2 hours after capture, be placed in special quarters. The quarters, whether in the field or in a zoo, must essentially simulate the natural environment. If this procedure is not followed, death may occur within a few hours or weeks, depending on which needs are neglected and the degree of neglect. The following brief history of experimental attempts to hold otters in various kinds of enclosures illustrates the requirements for exacting care.

The first modern U.S. attempt to hold captive sea otters was made in March 1951. Refuge Manager Robert D. Jones of the Aleutian Islands National Wildlife Refuge and a crew of men went to Amchitka Island aboard the U.S. Fish and Wildlife Service vessel *Brown Bear*. A camp was established at Crown Reefer Point, and at least 35 otters were captured on tidal rocks. An attempt to hold these animals in shallow, mud-bottomed, fresh-water lakes was unsuccessful. All died within a few hours or a few days after capture.

In February 1954, Drs. Donald Stullken and Charles M. Kirkpatrick, in company with U.S. Fish and Wildlife Service employees, visited Amchitka. Information about the physiology of sea otters and their behavior in captivity was obtained (Stullken and Kirkpatrick, 1955; Kirkpatrick et al., 1955). Otters were kept experimentally in two ways: (1) In a large wooden tank of sea water and (2) in an abandoned house where dry grass was used as bedding. All animals placed in the tank soon showed symptoms of shock and exposure, and died within a few hours or a few days. Of those kept on dry bedding, three were given constant attention and survived. They were brought to Seattle in June 1954 by R. D. Jones. Subsequently, when shipped to the National Zoological Park in Washington, D.C., and placed in a small inside pool, all died within a week.

In March and April 1955, 31 otters were captured at Amchitka, held on bedding of dry straw in a building, then placed aboard ship in small cages having dry bedding (fig. 107). Forty percent (12) of the animals died before leaving Amchitka or aboard ship. The remainder are thought to have died soon after liberation at the Pribilofs (see Transplant Attempts). It became obvious that if the captive sea otters' fur became soiled, the animals could not again clean their fur and survive after liberation in cold water.

My sea otter studies began on 26 July 1955, when one Aleut laborer, Antone Bezezekoff, and I went to Amchitka Island and remained until 5 October. Our primary purpose was to learn how to maintain captive sea otters in good health. We held otters ex-



F URE 107.—In 1955, before it was learned that fur of the sea otter quickly ost its waterproof qualities when otters were carried in dry bedding, these nimals were transported from Amchitka to the Pribilof Islands as shown. Mortality was high during the trip, and no otters are known to have survived after release. Three that were recaptured within a few minutes fter release were soaked to the skin, rigid with cold and near death. KWK 55–10–2)

rimentally in cages without water for bathing, since the 1954 idies had indicated that the otters survived best when kept dry. female, "Susie," was given constant care and brought to Seattle ere she lived in good health until shortly before her death on October 1961. The pelage of animals held for more than a nth in dry bedding became severely worn and matted. The fact t the otter which survived in Seattle did well in a pool demonated the need for access to clean water and dry areas.

Between 5 May and 26 July 1956, two experimental enclosures, th pools intermittently filled with water, were built on Amchitka. e of these was inside an abandoned building. Considerable midity developed, and the fur did not dry properly. All deoped enteritis and died within 2 or 3 weeks. Therefore, an outr enclosure was built containing a bathing trough through which sea water was pumped for 3 to 4 hours each day. When given only intermittent access to water, however, the waterproof condition of their fur eventually deteriorated. In addition, animals kept with limited access to water frequently developed infections of the paws and flippers which, in combination with eventual wetting of the underfur, contributed to the mortality. Although survival was improved in the outdoor cage, it was evident that caging methods were still inadequate.

In October 1957, an outdoor, cement pool, 15 feet (4.6 m.) long, 8 feet (2.4 m.) wide, and 4 feet (1.2 m.) deep, was built on Amchitka. Surrounding the pool was a wooden platform 7 feet (2.1 m.) wide, and the entire installation was surrounded by a board fence 7 feet (2.1 m.) high (figs. 108 and 109). The enclosure was unroofed. A continuous flow of water was furnished by a clear, fresh-water stream. All healthy animals placed in this enclosure remained healthy, and several that were afflicted with enteritis and apparently starving when captured regained health.

The basic reason for the failure of early experiments with captives became obvious. Under normal conditions in the wild, the

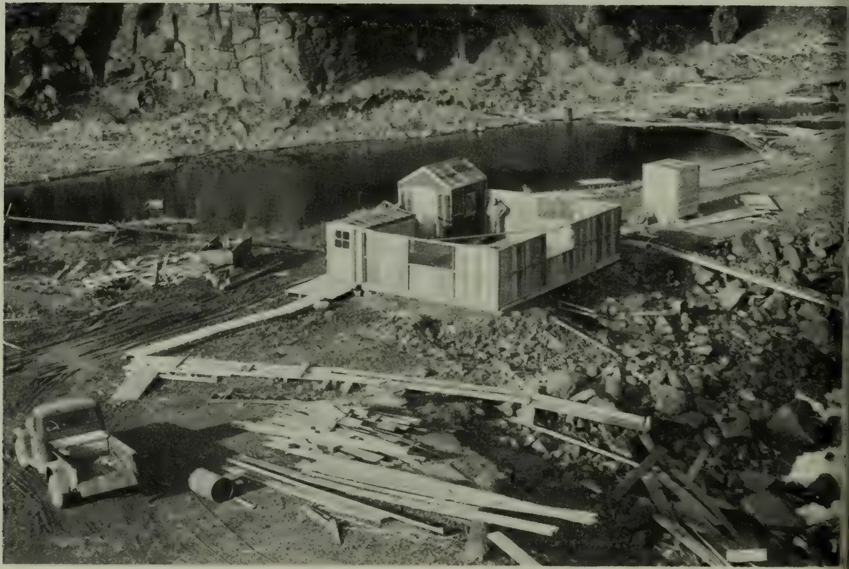


FIGURE 108.—This enclosure around a cement pool satisfactorily prevente escape and furnished ideal conditions where otters could be held indefinitel Water from a stream was brought to the pool in the wooden pipe, at lef A ramp was constructed (far right) on which a dory, used to obtain fis for otter food, was beached. Storm waves often destroyed the ram (KWK 57–27–12)

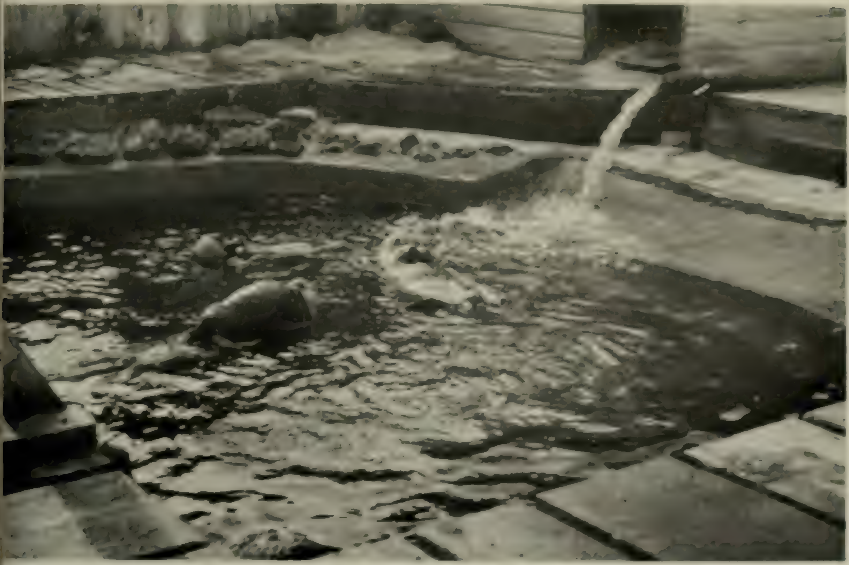


FIGURE 109.—The cement pool in the enclosure shown in figure 108 where otters were maintained in excellent health. (KWK 57-29-4)

sea otter exists only in clean water and the fur remains water-repellent. The skin is never wet but is protected by a blanket of air trapped in the fur fibers. The waterproof quality of the delicate fur is lost when animals are improperly held.

In shallow lakes (1951), mud and detritus became entangled in fur fibers, admitting water to the skin. In the large wooden tank (1954), an insufficient flow of water allowed suspended food and fecal matter to accumulate and become imbedded in the fur. Also, there was not enough space for the otters to get out of the water to dry themselves. The same results occurred as in the lake. When otters were given intermittent access to water (1956), food scraps and slime became imbedded in the fur during periods when water was not available. The progress of wetting was less rapid under the latter conditions because a degree of cleansing was possible. In addition, humidity developed with inadequate circulation of outdoor air and hindered the drying of fur when otters were held n a building.

Even in the large outdoor pool, built in 1957, care was necessary to limit the number of otters held. If more than five were held simultaneously, the pool had to be drained and cleaned daily to prevent an accumulation of food scraps and feces that affected the water-repellent qualities of the fur. Captive otters were not affected adversely by frigid temperatures (fig. 110) when held in proper enclosures.

No conclusive data are available to demonstrate that fresh water provides a satisfactory permanent environment for captive sea otters. Although no record exists to show that sea otters were ever found in fresh water in nature, captives held in clean fresh water at Amchitka showed no detectable ill effects. One female, Susie, lived for 6 years in a fresh-water pool in Seattle. An autopsy revealed, however, that her reproductive tract had not only failed to mature but had regressed and was less developed than in normal juvenile otters. Could this condition have been related to the fresh-water environment? In addition, severe infestation of nasal mites *(Halarachne miroungae)*, a condition never found in a wild otter, contributed to her death (Kenyon, Yunker, and Newell, 1965). I conclude that fresh water may be temporarily satisfactory for captive animals but that long-term studies of captive otters should be conducted on animals kept in sea water.

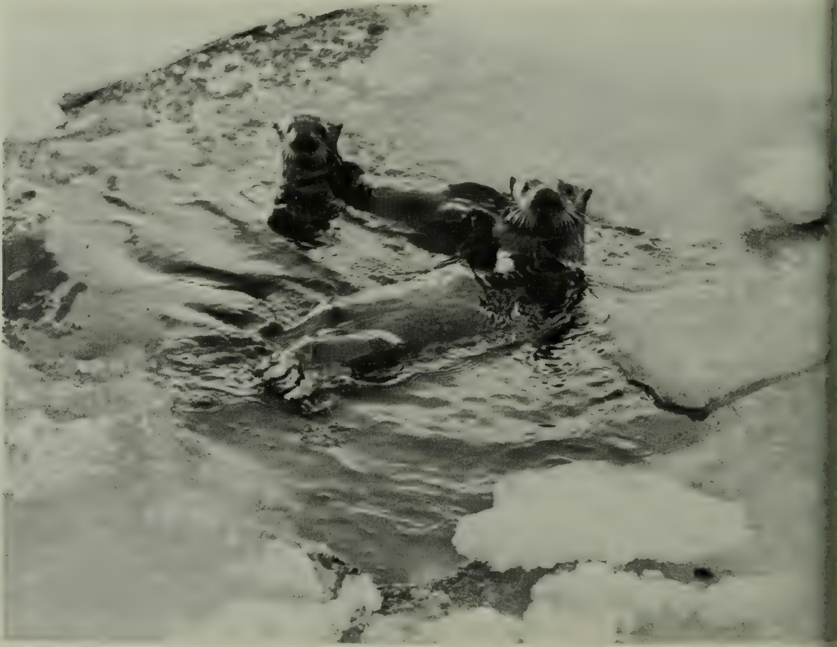


FIGURE 110.—Air temperatures down to +15° F. were withstood with no apparent detrimental effects by captive otters in the outdoor pool. Ice which quickly formed during cold spells was removed to provide open water. The otter in the foreground holds up its paws in typical begging posture. (KWK 59–3–1)

When bathing water was withheld, otters were kept in clean, ry litter for periods of several months. Upon reintroduction to ater, however, the fur, because it was soiled, immediately beame soaked to the skin. The otters shivered and showed distress Kirkpatrick et al., 1955). With special care, (drying the fur with wels and a warm air heater) or in warm weather, until waterroofness was restored, some captives survived this ordeal. Other armful effects of dry caging, fur wear and matting, probably nnot be remedied.

It was demonstrated that the sea otter is a hardy animal in ptivity if its basic and critical environmental needs are satisfied. must be kept in clean flowing water that washes away food raps and body wastes. Free air circulation that aids in drying e fur is also required. The sea otter, having no blubber layer, is pendent for heat retention entirely on the insulation afforded by r trapped within its fur. If the fur becomes soiled, allowing ater to reach the skin, chilling will result and if the animal is t artificially and quickly dried, death, often accompanied by teritis, follows soon. These findings agree with those of Soviet ologists (Reshetkin and Shidlovskaya, 1947; Marakov, 1965).

Food and Feeding of Captives

INDS OF FOOD OFFERED

Because the sea otter requires a large quantity of food, the eding of animals held captive in remote, isolated areas, posed oblems: (1) A large frozen food supply was seldom available;) transportation to replenish dwindling food supplies was not ailable and commercial facilities from which to obtain food ere hundreds of miles distant; and (3) fishing activities to obtain od in Alaskan waters were often interrupted by stormy weather.

For these reasons, experiments were conducted in the hope of veloping feeding methods requiring minimum expenditure of ne, money, and energy. Table 60 shows foods that were offered d the degree to which they were accepted. Since canned, salted, d dried foods were not readily accepted, the prospect of using ods that are easy to transport and store was abandoned.

Fishing with trammel nets in Constantine Harbor at Amchitka land was practical. The species taken in greatest number was inged greenling *(Hexagrammos decagrammus)*. Other species own in table 60 were taken in lesser quantity.

In 1955 and 1956 no refrigeration was available. Fish that were

TABLE 60.—*Foods offered to captive sea otters*

Food item	Acceptability	Remarks
Crustacea [1]:		
King crab (*Paralithodes*)	Preferred	A limited amount (2 to 3 lb. per animal) was eaten eagerly. If, however, fish was also available it was eaten and the remaining crab was left uneaten.
Tanner crab (*Chionoecetes*)	do	
Shrimp (misc. sp.)	do	
Mollusca [2]:		
Snails, mussels, limpets	Accepted	Eaten when hungry and nothing else available.
Clams (*Saxidomus, Chione*)	Preferred	Eaten to capacity if sufficient available.
Octopus (*Octopus*)	Highly preferred	Do.
Squid (*Loligo*)	do	Do.
Echinodermata [3]:		
Starfish (*Leptasterias*)	Refused	Sample bitten off then discarded.
Sea urchin (*Strongylocentrotus*)	Accepted	Eaten when gravid; refused when not gravid, and other foods available.
Pisces [4]:		
Herring (*Clupea*)	Accepted	Refused at first but eaten when nothing else available.
Salmon (*Oncorhynchus*)	do	Eaten reluctantly when nothing else available.
Arctic char (*Salvelinus*)	do	Do.
Lancetfish (*Alepisaurus*)	do	Do.
Cod (*Gadus*)	Preferred	Do.
Hake (*Merluccius*)	do	Do.
Rockfish (*Sebastodes*)	Highly preferred	Eaten regularly and consistently—many feedings.
Greenling (*Hexagrammos*)	do	Do.
Lingcod (*Ophiodon*)	do	Do.
Sculpin (*Hemilepidotus*)	do	Do.
Poacher (*Agonus*)	Accepted	Eaten when nothing else available.
Globefish (*Cyclopterichthys*)	do	Do.
Halibut (*Hippoglossus*)	do	Do.
Sole (*Lepidopsetta*)	Preferred	Do.
Canned fish (salmon, mackerel, sardines)	Refused	Refused even when very hungry.
Cooked fresh fish (Greenling, boiled)	do	Do.
Salted and brined (codfish)	Sampled	Small amount eaten reluctantly.[5]
Aves: Goose flesh (*Philacte*)	Taken	Eaten reluctantly when very hungry but passed through tract undigested (Stullken and Kirkpatrick, 1955).
Mammalia: Seal flesh (*Phoca*)	do	Do.
Mink food	Refused	Dried commercial mink food was mixed with fresh fish. Not eaten even when hungry.

[1] Large pieces of shell discarded but many small pieces swallowed. J. Vania found that captive otters took live Dungeness crabs (*Cancer magister*) eagerly and were preferred to the exclusion of other foods during extended periods.

[2] Clam shells discarded but small shells of mussels and snails crushed and swallowed.

[3] Many pieces of shell swallowed.

[4] Viscera and hard bones of head discarded but other bones and skin usually swallowed.

[5] Soviet biologists apparently successfully fed salted cod and haddock after soaking "8–10 days in winter, 4–5 days in summer" (Shidlovskaya, 1947). Our otters might have taken some of the food items that were refused if they had been allowed to become sufficiently hungry.

alive when removed from nets were stored until needed in cages suspended in sea water from Kirilof dock.

Most fish taken at Amchitka were heavily infested with the roundworm *Terranova decipiens*. This parasite was tolerated in small numbers by sea otters but when heavy infestations were accumulated in captive animals they became lethargic and exhibited malaise. On autopsy, intestines of juveniles were found to be perforated by the worms. After 1956, all fish given to captive otters were held frozen (at about +10° F.) for at least 24 hours. Apparently all helminth parasites were killed by this treatment.

A Soviet biologist (Shidlovskaya, 1947) states that fresh fish "is always better than frozen fish." Our experience is not in accord with this statement. During extended periods in captivity, otters were regularly fed fish that had been frozen and health remained excellent.

FOOD QUANTITY REQUIRED

During the period March 1956 through December 1957, records of the food consumed by Susie, a captive female sea otter, were kept on 602 days. Keeper Richard D. Clark used a 25-lb. capacity, Chatillon, platform-spring scale to weigh all food to the nearest ½ lb. (occasionally to ¼ lb.). The otter was fed three times daily (morning, noon, and late afternoon). Food in excess of the otter's daily consumption was offered. Before the morning feeding, the pool was drained and all food scraps from the previous day were removed and weighed. From these data the approximate weight of the food consumed was calculated. A screen over the pool drain minimized loss of remnant food scraps. The data from the daily feeding record are summarized in table 61.

The weight of this female (six weighings) averaged 39 lb. (17.7 kg.). She consumed about (daily average, 1 year, 1957) 8.9 lb. (4.04 kg.) or about 23 percent of her body weight per day, approximately 228 g./day/kg. of body weight. The extremes, using monthly averages were 24 percent (in February) and 20 percent (in April) of body weight consumed per day.

The actual daily consumption of food ranged from a minimum of about 2 lb. (0.9 kg.) to 16 lb. (7.2 kg.). The range in amount

TABLE 61.—*Food consumption of a 39 lb. (17.7 kg.) sea otter (Susie) at the Seattle Zoo*

		Kilograms of food				
				Extremes of average daily intake[1]		
Observation period	Days data kept	Total food offered	Total food consumed	Maximum	Minimum	Average daily intake entire period
March–31 December 1956[2]	261	1,587.3	930.2	4.17	2.95	3.56
January–15 December 1957[3]	341	2,129.6	1,374.7	4.31	3.54	4.04
Total (and mean)	602	3,716.9	2,305.0	4.24	3.24	3.81

[1] The average daily intake during each month was computed.

[2] Except August when no data were kept.

[3] A second otter was placed in the enclosure at the end of this period.

eaten was between 4.5 lb. (2.0 kg.) and 11.5 lb. (5.2 kg.) 94 percent of the time and between 5.5 lb. (2.5 kg.) and 10.5 lb. (4.8 kg.) 78 percent of the time (fig. 111).

Figure 112 demonstrates that in a winter month (February) more food was consumed than in a summer month (August). In February the intake in a 24-hour period ranged from 6 lb. (2.7 kg.) to 14.5 lb. (6.6 kg.) and in August from 5 lb. (2.3 kg.) to 12.5 lb. (5.7 kg.). The average daily consumption in February was 9.5 lb. (4.3 kg.) and in August 8.8 lb. (4.0 kg.). About 3,400 and

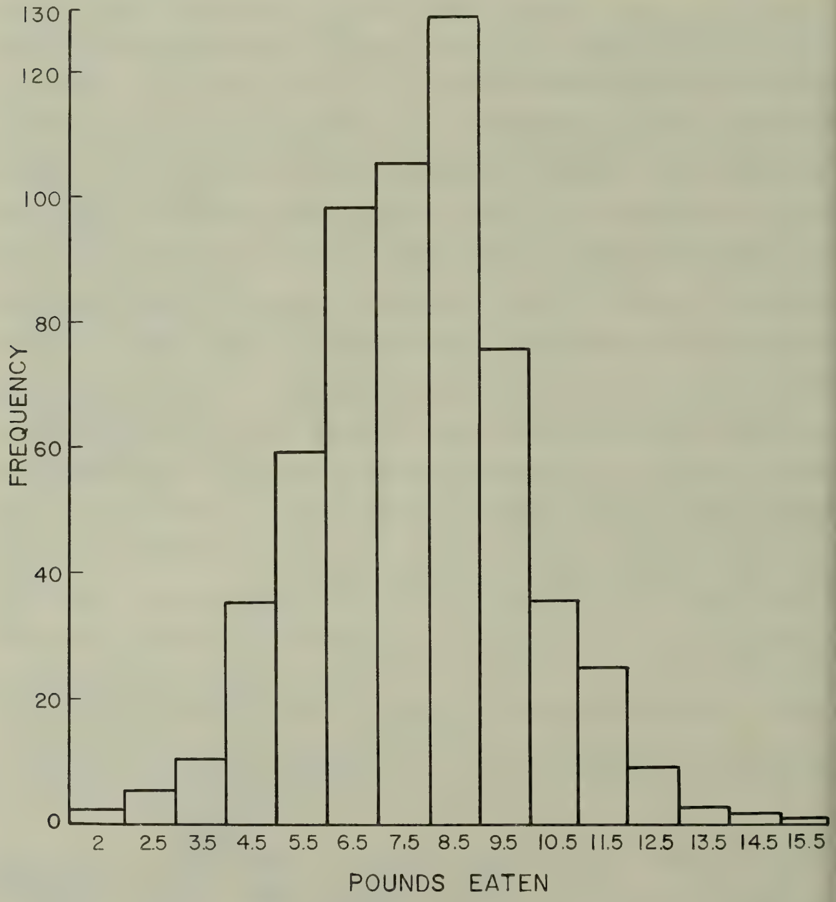


FIGURE 111.—The amount of food consumed by a captive female otter was recorded on 602 days. Food was available in excess of her daily requirement and the amount consumed in a single day varied from about 2 lb. (1 kg.) to 16.5 lb. (7.5 kg.). Daily consumption was between 4.5 and 11.5 lb. on 567 days (94 percent of the time) and between 5.5 and 10.5 lb. on 470 days (78 percent of the time).

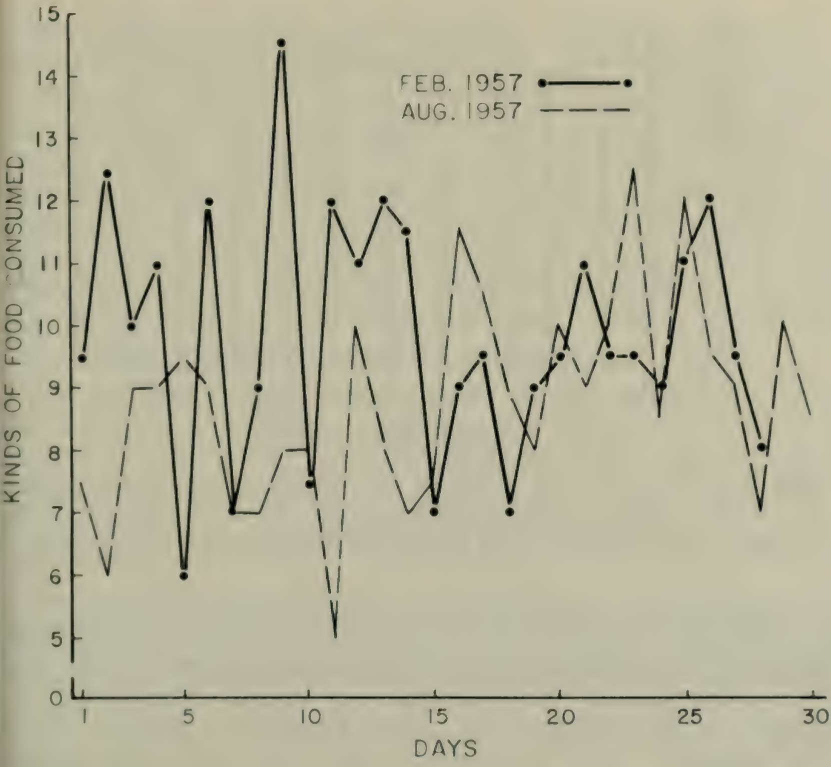


FIGURE 112.—Daily food consumption of a 39-lb. female sea otter (Susie) during a midwinter month (February) and during a midsummer month (August). More food was always available than was consumed. Average consumed in August, 8.8 lb.; average consumed in February, 9.5 lb.

3,200 calories per day were consumed in these winter and summer months, respectively, i.e., about 5 percent more in February than in August. The seasonal variation in consumption of food, however, was inconsistent (fig. 113) probably because water temperatures did not fluctuate greatly (seldom near freezing in winter to about 65° F. in summer), when compared to temperature fluctuations in other environments.

The average daily intake per month varied from 7.2 lb. (3.24 kg.) to 9.3 lb. (4.24 kg.), or from about 183 to 240 g. per kg. of body weight per day. It is interesting to note that dogs of 10 to 20 kg. daily require about 70–80 calories per kg. of body weight and the sea otter requires about 190 calories per kg. per day.

From December 1957 until September 1958, a nearly adult male, Dave, shared Susie's quarters. During the period January

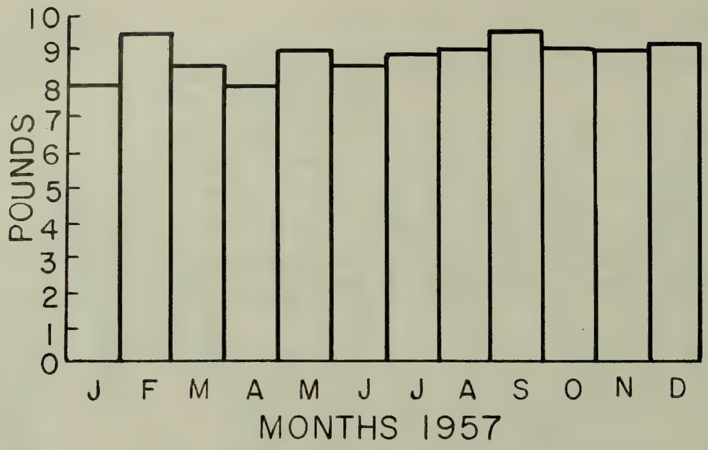


FIGURE 113.—Average daily weight of food consumed each month in 1957 by an adult female sea otter weighing about 39 lb. In this period the average daily consumption was 8.8 lb. (23 percent of the body weight).

through August, records were kept of their combined food intake. The combined weights of the two animals was about 102 lb. and they consumed (during 212 days when records were kept) an average of 25.1 lb. of food daily, or 24.6 percent of their combined body weights. Unless competition for food stimulated Susie's appetite and increased her intake, this would indicate that the rate of consumption of the male exceeded that of the female.

An adult male, Gus, now (1967) in the Tacoma Aquarium kg.), about 20 percent of his body weight, of fish and squid daily. weighs 76 lb. (34.5 kg.) and rarely fails to consume 15 lb. (6.8 His food is stored frozen in 5 lb. (2.3 kg.) blocks and three of these are offered daily (filleted rockfish morning and evening and squid at noon). From 1 September 1966 through 31 August 1967 he consumed 5,452 lb. (2,473 kg.) of food. During the year period, the otter consumed more than 99 percent of the food offered. When, on several occasions, more than 15 lb. of food was offered the otter either refused it or did not consume the entire ration at a subsequent feeding. On his uniform and regulated diet this otter appeared to remain in excellent condition.

Some captive otters were temperamental about their food. A food that was eaten enthusiastically one day was ignored or eaten reluctantly the next. This behavior was especially evident when an abundant supply of food was available. Days of high consumption might indicate that a fresh supply of particularly desirable food was available.

When the food supply was limited on Amchitka and several otters were held simultaneously in a pool, we found that large juveniles, weighing 20 lb. (9 kg.) to 30 lb. (14 kg.), maintained health and vigor when fed a minimum daily average of about 6 lb. (3 kg.) of food per animal and that adults could subsist on a minimum average of about 8 lb. (4 kg.) fed daily per animal in morning, noon, and evening feedings. Given these quantities, the animals were always hungry and tended to rob food from each other. Stullken and Kirkpatrick (1955) found that when captives held in dry bedding were given only about 12 to 15 percent of their body weight per day enteritis developed.

The northern fur seal which, unlike the sea otter, has a thick blubber layer in addition to its fur, was found to require only about 7 percent of its body weight in food per day (Scheffer, 1950b).

Conclusions

When food was offered daily in excess, the average daily consumption by a female during 602 days was about 23 percent of the body weight. The daily consumption varied greatly. Consumption per day ranged from about 5 percent to 40 percent of the body weight. This animal appeared to be in excellent health during the study period.

When a captive male was offered food that was limited to 20 percent of his body weight each day, he consistently ate the amount offered and remained vigorous and healthy.

At Amchitka when a sufficient number of fish could not be caught, otters were held temporarily in apparent good health on less than the optimum food requirement. Food representing 15 percent of the body weight per day was near the minimum temporary requirement.

COST OF FOOD

Inquiries have been received concerning the economic possibility of operating a sea otter "fur farm." Aside from the high expense of catching and transporting the animals and building suitable quarters for them, the cost of feeding would be an important consideration.

For 1 year a record was kept at the Seattle Zoo of the cost to feed an adult female sea otter (Susie). The information was given to us by Zoo Director Frank Vincenzi (letter, 8 April 1963) and is summarized below:

Clams—20 lb./week at 20 cents/lb. 52 weeks	$ 208.00
Octopus—346 lb. at 20 cents/lb.	69.20
Fish—11,658 lb. at 10 cents/lb.	1,165.80
Total cost of food—1 year	$1,443.00
$27.75/week or $3.96/day	

The cost of food for Gus in 1 year, 1 September 1966 to 1 September 1967, was more than $1,650 (squid at 30 cents per pound and filleted fish varied from 30 cents to 35 cents per pound). Point Defiance Aquarium Director Cecil Brosseau considers that the annual food cost is close to $1,800 or about $5 per day.

FEEDING BEHAVIOR OF CAPTIVES

When captives were kept in ample water they ate readily. Certain individuals consumed food eagerly immediately after capture. Others, in apparent good health, refused to eat for 24 hours or slightly longer. Old and apparently ill animals sometimes refused to eat, or ate too little to survive.

Within 1 or 2 days of capture, captives learned to beg for food and even after storing a quantity under the foreleg would float on their backs, both forepaws upheld in a begging posture (fig. 114). Food was usually tossed to otters individually as they floated on their backs. Pieces of fish were sometimes caught between the forepaws but more usually the food item was allowed to strike the chest before it was grasped by the paws. Often when an attendant entered the enclosure carrying a bucket of fish the more aggressive individuals would rush from the water to take food from the hand (fig. 62). At such times they never attempted to bite and would take food lying flat on an extended hand, avoiding contact between teeth and fingers.

Large adults habitually robbed smaller adults and juveniles, even when the larger ones had all they could carry under the forelegs. The robber would approach the victim from behind or beneath and with one or both forepaws wrench the food from the smaller animal's chest (fig. 115). Certain aggressive adult females growled and snapped at a robbing male, but juveniles and subordinate adults offered no resistance other than to roll away from the robber. Frustration, or perhaps anger, was expressed by the victim at such times by slapping the chest with rapid strokes of both forepaws.

Because food reserves were often low, it was difficult to assure that all captives received sufficient food. To reduce pilferage, a bamboo pole was used to deter food-robbing animals. One adult female, however, became so adept that while diving and projecting

IGURE 114.—Juvenile otters learned begging behavior within a day or two after capture. The paws were held up and when a piece of fish was thrown (in circle) the otters attempted to catch the food. Sometimes a food item was caught by the paws, but usually it struck the chest. (KWK 59–14–13)

o more than one foreleg above the surface, she could quickly natch all the food from the chest of a large juvenile floating and ating on the surface. After repeated treatment with the stick, he learned not to rob her pool mates as long as an attendant tood near the pool with the stick.

Kirkpatrick et al. (1955) described how captives ate a variety f food items. During our studies at Amchitka, fishes (head and iscera removed) weighing a pound or less, were the most frequently offered food. Young animals often had difficulty in cutting he fishes' tough skin and reducing the flesh to bite-sized chunks. The fish was held between the forepaws, while the chunks, torn from the body with the canines and incisors, were crushed by the postcanines before swallowing. Bones were often discarded. When whole fish were given, the viscera were not eaten. Sometimes the tail and skin of the fish were eaten. As noted by Stullken and Kirkpatrick (1955), only bones, shells, and calcareous spines passed through undigested.

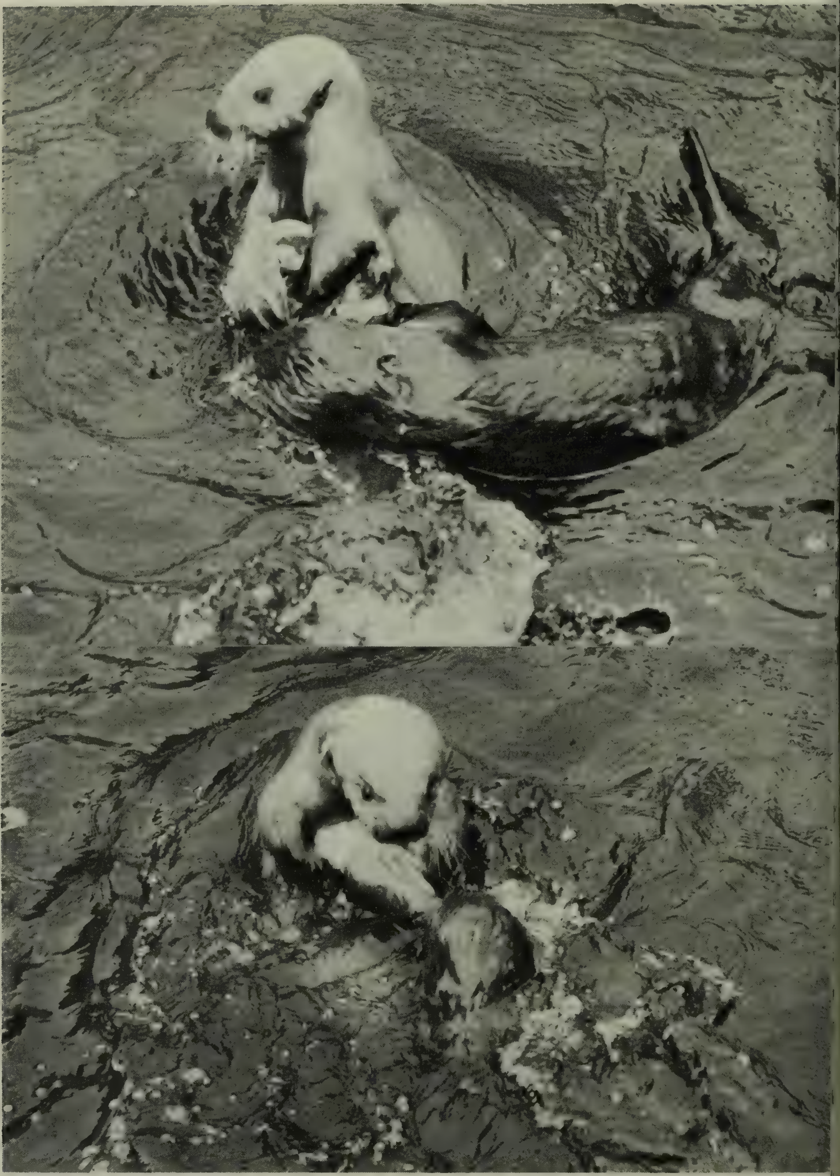


FIGURE 115.—*A*—A large and unusually light-colored adult female aggre sively wrenched a food item from a juvenile otter. After grasping tl food tightly to her chest with the forelegs, the adult rolled away ar dived. The young otter was unable to retrieve any food after it had bee stolen. *B*—The juvenile attempts to retrieve a fish which the adult fema had stolen from it. The adult, after rearing back, rolled forward ar dived, frustrating the attempts of the juvenile to retrieve its foo (KWK 59–13–3 and 4)

Wild sea otters habitually eat while floating on the surface (see ood and Feeding Behavior). When captives were held in enosures without sufficient water to swim in, they ate poorly. They efused some foods that were readily eaten by captives held in a ool. They were nervous and distressed. Stullken and Kirkpatrick 1955) noted that three successfully maintained captives kept in ry bedding lost weight, frequently appeared listless, and in eakened condition during the first 10 days in captivity. Digestion as apparently disturbed when animals were kept on dry bedding ithout a pool. Flatus was observed frequently in otters kept on ry bedding but not in animals kept in a satisfactory pool. Similar ood was given to both groups of animals.

Individual animals in apparent good health refused to eat when eld on dry bedding without access to a pool. One adult male efused to eat for 4 days and was then released, weakened but till apparently healthy. An adult female kept in similar quarters efused food for 6 days before release. Juveniles, in general, were ore adaptable than adults. Sea otters require an abundant supply f clean water in which they can consume food and clean their elage while eating. Only while in transit for a brief period should hey be held in cages without bathing water.

Daily Cycle of Activity

EHAVIOR DURING THE DAY

Two days, one in midsummer (29 August 1957) and the other n midwinter (21 January 1960) were spent by V. B. Scheffer and ne near the enclosure of an adult female sea otter (Susie) in the eattle Zoo. Her activities as listed below were timed with a stop atch and recorded (table 62). Activities were classified according o four primary categories:

rooming

Rubbing the fur with the paws, principally the forepaws. It was ccomplished while sitting beside the pool or while rolling over nd over in the water or lying on the surface of the pool.

Resting

When the eyes were shut the otter was presumed to be sleeping. If the eyes were open while she lay quietly, she was recorded as apping.

TABLE 62.—*Activity of a captive sea otter in daylight hours, summer (1957) and winter (1960)*

[Air temperature: 29 Aug. 1957 at 0515, 52° F. (11° C.); at 1200, 70° F. (21.5° C.); at 1900, 66° F. (19° C.)]

	Minutes						Percent of total	
	In water		On land		Total			
Activity	29 Aug.	21 Jan.	29 Aug.	21 Jan.	29 Aug.	21 Jan.	29 Aug.	21 Jan.
Grooming:								
Energetic	239	86	100	103				
Languid	106	11	0	17				
					445	217	48	40
Resting:								
Sleeping	19	0	63	13				
Napping	84	19	6	38				
					172	70	19	13
Feeding	81	63	0	0	81	63	9	12
Exercise:								
Swimming	190	185	0	0				
Walking	0	0	5	0				
Playing	22	5	0	0				
					217	190	24	35
Total	741 (81%)	369 (68%)	174 (19%)	171 (32%)	915	540	100	100

Feeding

Food was placed in the otter's pool at about 0900, 1230, and again in late afternoon if none remained. Food remaining overnight in the pool was eaten by the otter before her regular feeding time. Feeding activity was most intense shortly after fresh food was placed in the pool. At other times, food items were retrieved from the bottom and eaten.

Exercise (swimming)

Like many zoo animals, the sea otter developed an exercise routine during which she circled her pool. In a certain place she would dive, in another she rose to the surface and turned, swam a short distance on the surface, then dived to complete the circuit. If a number of visitors stood near the fence by her pool, the exercise routine might include a vertical rise with one forepaw on the pool edge while she glanced at the visitors. This was also done before feeding time, when she glanced in the direction from which the keeper would come. Occasionally the otter left the poo to walk briefly about her enclosure. Such short walks did not follow a set pattern similar to the swimming routine. Play was recorded when the otter picked up leaves, peanut shells, or scrap of paper and with her teeth and forepaws bandied it about also when small rocks were retrieved from the bottom of the pool and pounded in an apparently aimless way on the edge of the pool. This activity apparently became an exercise routine

Because of the frequency with which it occurred, the edge of the pool eventually became damaged and zoo officials removed the rocks from the pool.

The primary purpose of these observations was to ascertain whether behavior differed in response to temperature or other environmental seasonal conditions. All conditions, except those associated with season, were similar in the two observation periods.

On 29 August the weather was clear and calm. On 21 January a high overcast persisted until 1300, after which the sky remained clear until sunset.

The summer maximum temperature was 26° F. (18.5° C.) above the winter maximum and the winter minimum was 17° F. (9.5°C.) below the summer minimum on the days of observation. This temperature difference and the difference in hours of daylight (4 hrs., 13 min. less in winter, table 63) apparently did not materially affect the otter's general pattern of daily activity. In spite of the differences in these environmental conditions, the percent of time that the otter spent in the four main activities recorded are similar (table 62).

The amount of time that the otter spent on land, however, showed seasonal differences. On the summer day the otter was in the pool both at sunrise and at sunset. On the winter day she was in her den at both these times. Also, in the winter she spent a greater percent of her time during the day on land, even though her actual time on land was nearly identical (174 and 171 minutes, table 62).

Figure 116 shows the distribution of activity by minutes throughout the summer day. (Because of its similarity, a chart for the winter day is omitted.) This shows that grooming periods were generally distributed through the day, that periods of exercise were concentrated in morning and late afternoon hours, and that periods of rest reached greatest frequency at midday and in the afternoon. There were five prolonged rest periods of relative inactivity on the summer day: from 1126 to 1222, from 1340 to 1430, from 1502 to 1542, from 1733 to 1831, and from 1907 to 1944.

Table 62 demonstrates that the amount of time spent in muscular

TABLE 63.—*Conditions during sea otter observations at the Seattle Zoo*

	29 August 1957	21 January 1960
Sunrise	0527	0740
Sunset	1853	1653
Hours of sunlight	13 hrs. 26 min.	9 hrs. 13 min
Air temperature (range)	52° to 70° F.	35° to 44° F
Water temperature (constant)	62° F.	38° F.

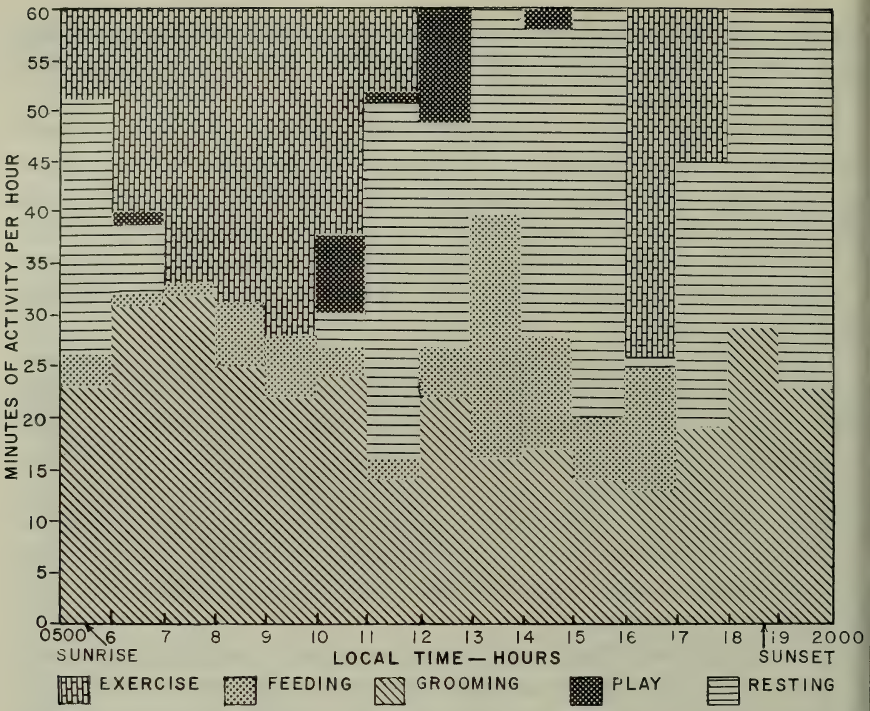


FIGURE 116.—The activities of a captive female sea otter were recorded for each minute from before sunrise to after sunset on 29 August 1957. The minutes spent in five categories of activity are summarized above for each hour of observation.

activity, grooming and exercising combined, was similar (72 percent in summer and 75 percent in winter). Grooming activity, however, consumed more time in summer than in winter.

Daily activity of wild and captive otters

The daily pattern of activity of the captive female and a wild female sea otter (further data are in the section on Breeding Behavior) would be expected to show obvious differences because a wild otter must search for food. Table 64 illustrates the differences. The data (although recorded in the same manner) are not strictly comparable because the captive otter was observed from the time of awakening in the morning until retiring at night. The wild otter was observed only from 1052 until 1820 (local time, Amchitka Island). In general, however, this comparison illustrates the fact that a wild otter must spend more than one-half of its time in feeding while the captive spent less than 10 percent of her

TABLE 64.—*Comparison of daily activities of wild and captive female sea otters in summer*

Activity	Wild otter 21 August 1955[1]		Captive otter 29 August 1957	
	Minutes	Percent	Minutes	Percent
Feeding	257	55	81	9
Grooming	50	11	445	48
Resting	126	28	172	19
Exercise and play	25	6	217	24
Total	448	100	915	100

[1] See Breeding Behavior for further data.

time in this activity. The wild otter nearly satisfied her need for exercise while diving for food. The captive satisfied this need by swimming and grooming to a greater degree than the wild otter. The percent of time devoted to rest by both animals differed the least.

BEHAVIOR AT NIGHT

From 1 January to 9 September 1958, Mr. Cal Pierce, night watchman at the Seattle Zoo, recorded observations of the behavior of two captive sea otters. The objective was to obtain observations of the time each animal spent in and out of the water and in the den. For a variety of reasons, some nights were missed; substitute watchmen did not always properly record the data. Usable observations were taken on 199 of the 252 nights. Observations were usually made at hourly intervals from 1800 to 2200, and two to four times between 2200 and 0600. Usually the watchman recorded only whether each animal was in the pool, beside the pool, or in the den. Two dens were available, and both sea otters always had free access to all areas within their enclosure. Weather conditions were not recorded during the observation periods, but on several occasions the watchman noted that even during heavy rain the otters remained in the open, sleeping in or beside their pool.

Feeding, grooming, and play were not recorded systematically, but were noted on a number of occasions at various times during the hours of darkness up to about 2200. During late night and early morning hours, however, the animals usually slept quite soundly. Sometimes they awoke with a start in the light of the watchman's flashlight. If beside the pool when awakened, they immediately plunged into the water; if sleeping on the water, they would dive.

Observations made after 9 September are not used. About this time the behavior of the male became abnormal, and he spent increasing amounts of time in the den. His health steadily deteriorated and he died on 22 September.

The general behavior pattern for each animal during the night is indicated in figures 117 and 118. Both animals tended to remain in the water more than out of it during the early evening hours. During late night and early morning hours, the male spent a nearly equal time in and out of the water while the female tended to spend more time out of the water than in it. Both animals preferred to remain out of doors, whether sleeping on the pool edge or in the water, but the female consistently spent more time in the den than did the male.

Even during winter months the sea otters seldom sought shelter in the den (figs. 119 and 120). The amount of time spent in the water at night, however, was greatly reduced in winter months. The male spent only 20 percent of the night in the pool during January. During the spring and summer the amount of time he

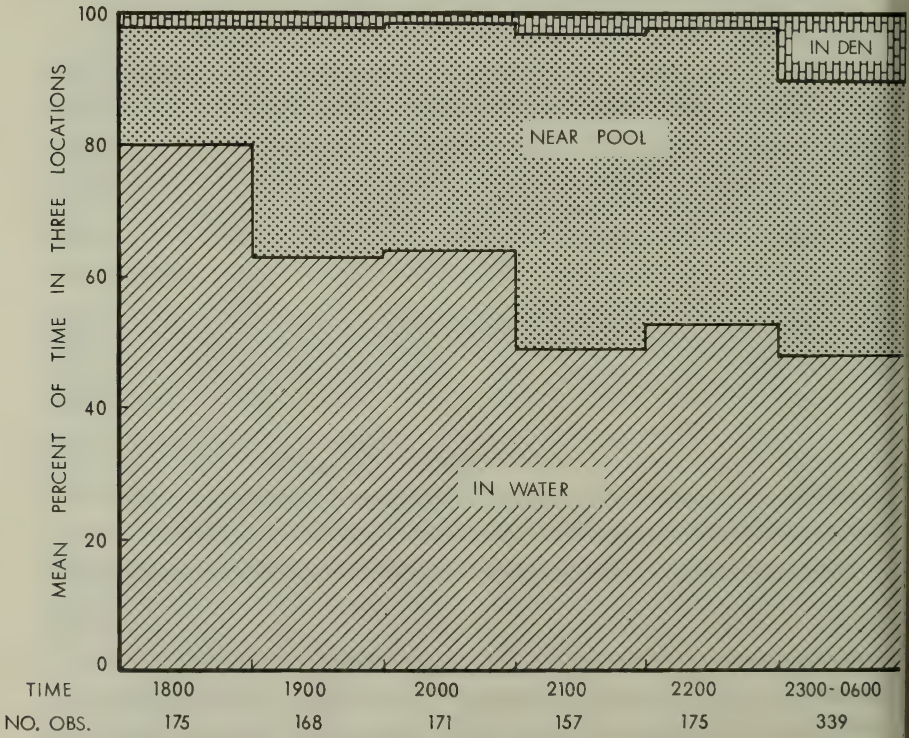


Figure 117.—Behavior of an adult male sea otter during a mean or average night. The mean percent of 1,185 observations of the animal in three locations during the night are shown.

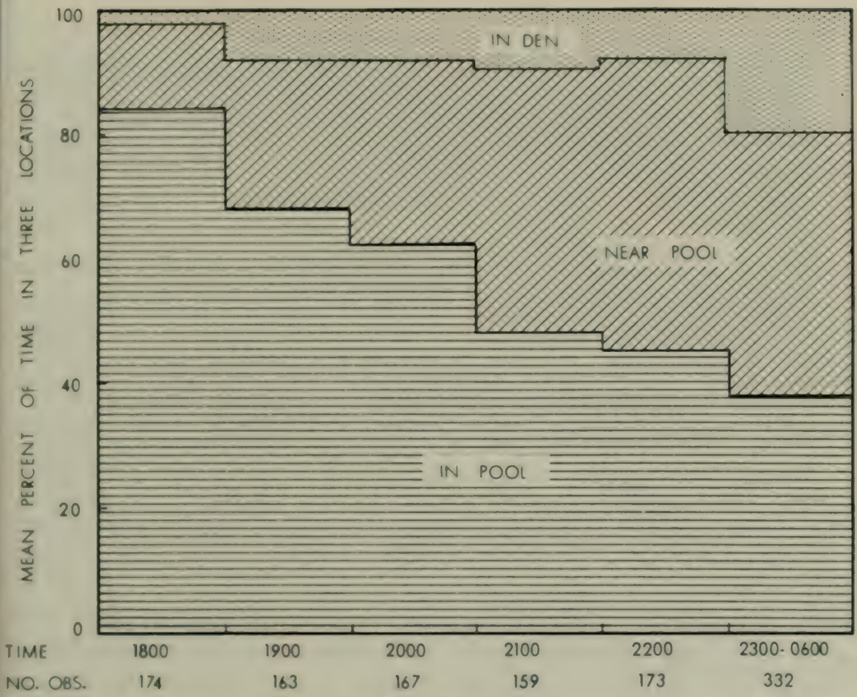


FIGURE 118.—Behavior of an adult female sea otter during a mean or average night. The mean percent of 1,168 observations of the animal in three locations during the night are shown.

spent in the water increased until in June he spent about 90 percent of his time there.

Causes of Death in Captivity

This subject was discussed in the foregoing pages in relation to environmental needs of captive otters.

The terminal symptom noted at death was often the voiding of black, tarry feces. Necropsy revealed enteritis (Stullken and Kirkpatrick, 1955).

K. L. Binkley, D.V.M., described the condition he found in three adult or near adult otters which he transported from Amchitka Island on a commercial, passenger-carrying aircraft (from a typewritten report dated 5 November 1957, in the files of the U.S. Fish and Wildlife Service):

Cause of death; acute pulmonary hemorrhage. Predisposing factors; high altitude flying in a nonpressurized plane, and promazine induced tranquility.

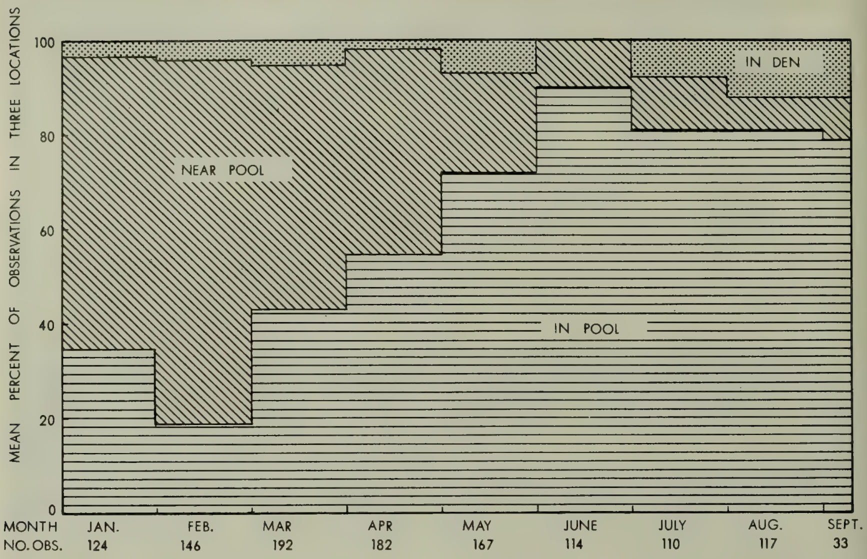


FIGURE 119.—Seasonal behavior of an adult male sea otter at night. The mean percent of 1,185 observations of the animal in three locations during 9 months is shown.

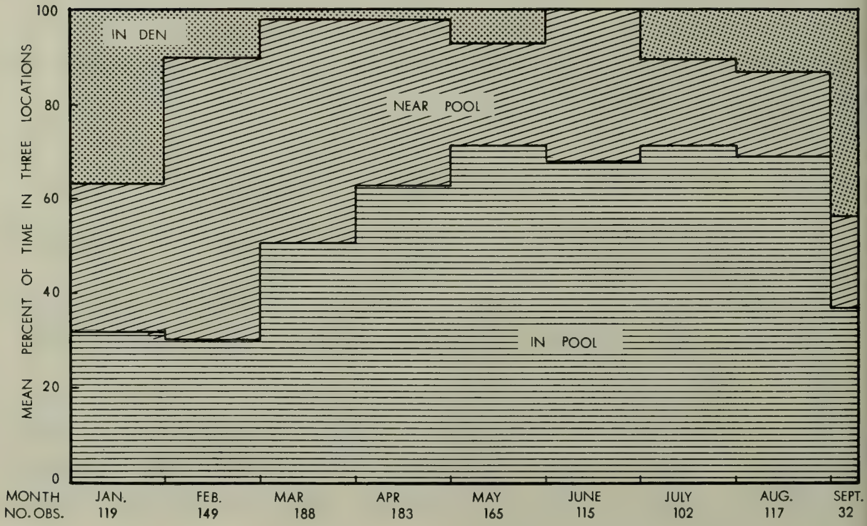


FIGURE 120.—Seasonal behavior of an adult female sea otter at night. The mean percent of 1,170 observations of the animal in three locations during 9 months is shown.

Administered 1.8 cc. Sparine. (Based on a dose of 2 mg. Sparine per lb. body weight, the weight was 43 lb. which resulted in a total dose of 90 mg. Sparine comes 50 mg./cc.) Dose administered approx. 0900 hrs 2 November, the animal died 1230 hrs 2 November. Lungs completely hemorrhagic. Trachea extremely hemorrhagic. Blood dark red, tarlike coagulations. Heart showed compensatory enlargement. Liver pale and anemic looking. Remaining organs normal with some postmortem discoloration. Stomach partially filled with food.

Overheating was probably also an important factor in the deaths of these animals. Post mortem examinations revealed that three captive otters were suffering from intussusceptions of the small intestine. This condition prevents the normal passage of intestinal contents. The reason that it occurred is not known but I suspect that stresses created by unsatisfactory holding facilities and during travel were important factors.

In review, captives died (1) as a result of chilling when the fur became soiled and its insulating air blanket was destroyed, (2) as a result of heat prostration in heated compartments when deprived of bathing water, (3) when infections occurred in the extremities, (4) when old and ill animals failed to eat after capture, (5) when parasitic roundworms *(Terranova)* ingested with fish flesh penetrated the intestine and caused peritonitis, (6) of lung hemorrhages when "tranquilized" otters were carried in small cages aboard a heated, passenger-carrying aircraft, (7) of lung congestion caused by a heavy infestation of nasal mites *(Halarachne)* (Kenyon et al., 1965), and (8) of intussusceptions of the small intestine. Enteritis was a frequent terminal condition. Causes of death are discussed further in the section on Parasites and Miscellaneous Diseases.

In conclusion, when parasite-free food requirements are met and the essential physical features of the sea otter's marine environment are duplicated, it adjusts easily to a healthy life in captivity.

Drug Use

Certain drugs were found useful in the care of captive otters. If drugs had not been used, some captives that survived probably would have died. No attempt was made to use drugs fired from a gun to capture sea otters.

Nembutal

Stullken and Kirkpatrick (1955) found that the normal anesthetic dose for dogs (40 mg. per kg. or 80 mg. per lb. of body weight) injected intraperitoneally caused death in a sea otter in less than 30 minutes. One-half the dog dose gave good anesthesia but thermoregulation was upset. No further experiments with Nembutal were conducted.

Promazine hydrochloride "Sparine" (Wyeth)

The use of this tranquilizer was suggested by K. L. Binkley, D.V.M. It was found to be a useful agent in speeding the adjustment of nervous animals to captive conditions. The dosage of 1 mg. of Sparine per kg. (2 mg. per lb.) of body weight was satisfactory. The intramuscular injection took effect within 5 minutes. The animals so treated remained in a relaxed state for about 24 hours. This degree of sedation is, however, usually unnecessary and under certain conditions harmful, since food intake and pelage care were substantially reduced during the tranquilized period. We found that about half this dose or less, i.e., about 0.5 to 1 mg. Sparine per lb. of body weight, induced adequate tranquility and that the otters gave nearly normal attention to their bodily needs. When the effects of the drug wore off, the treated animals in all cases remained tame and well adjusted.

Sparine was particularly useful when mothers with small pups were captured. On one occasion a mother with a newborn pup was placed in the enclosure without receiving an injection. The mother grasped the pup in her mouth and swam frantically about the pool seeking escape (fig. 121), rather than swimming in the normal manner on her back with her pup on her chest. She surely would have drowned the pup if we had not recaptured her, taken the pup from her, and given her the minimum injection. Within 5 minutes we returned the pup and the mother cared for it in the normal way from then on (fig. 122).

Usually when a sea otter pup was taken from its mother it cried almost incessantly, day and night, and accepted little food voluntarily. We found that after a minimum injection of Sparine such orphans became calm and after the effects of the drug had disappeared the pup appeared to have become "imprinted" on the human foster parent. Treated pups readily accepted food and only cried when desiring attention. Unfortunately, time and facilities were not available to maintain helpless captives indefinitely.

No harmful side effects from minimum injections of Sparine were detected in otters kept in a satisfactory enclosure with a pool. Because it was important that sea otters give frequent attention to their pelage and maintain their daily intake of food, it was desirable that use of tranquilizers be kept to a minimum. The

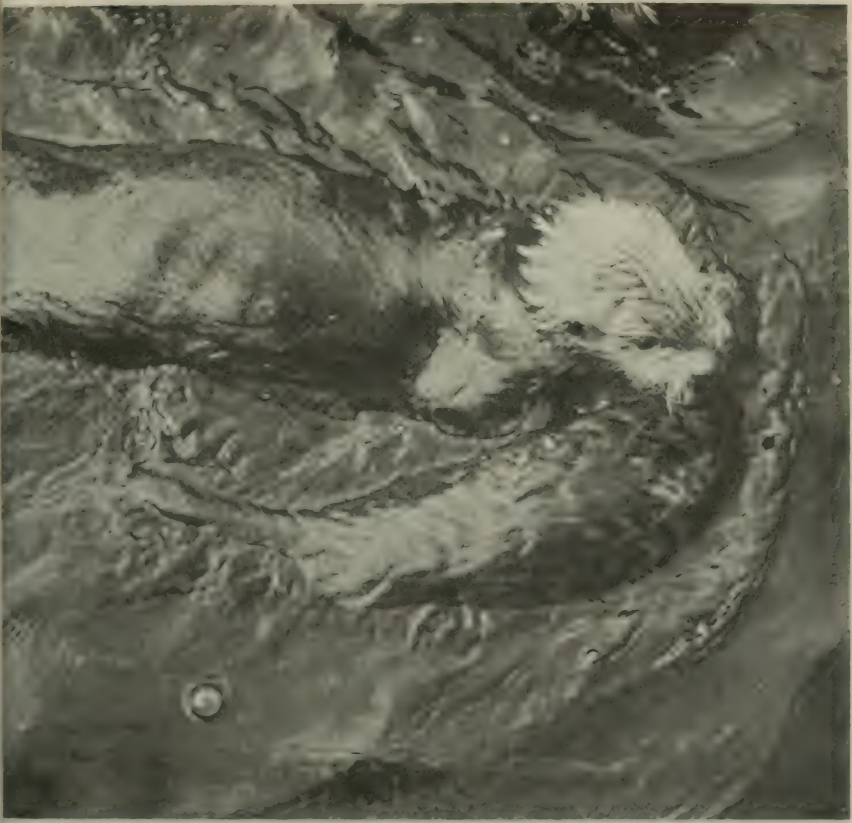


FIGURE 121.—A mother otter was placed in the pool without receiving a tranquilizer. Frantically she searched to escape while swimming about the pool, holding her pup in her mouth, the pup's head under water. Mother and pup were netted and the mother was given a small dose of Sparine (0.5 mg. per lb. of body weight). (KWK 57–29–31)

degree to which the use of Sparine on animals carried aboard an aircraft contributed to their deaths in transit is unknown (see Causes of Death in Captivity).

Propiopromazine hydrochloride "Tranvet" (Diamond)

This tranquilizer was used successfully by biologists of the Alaska Department of Game. Injections were given to captives immediately after capture (about 0.05 to 0.1 mg. per kg. or 0.1 to 0.2 mg. per lb. of estimated body weight). Before placing otters aboard aircraft during transplanting operations, a second dose of the drug, twice the amount of the first, was injected. J. Vania told me that the animals became satisfactorily relaxed and showed

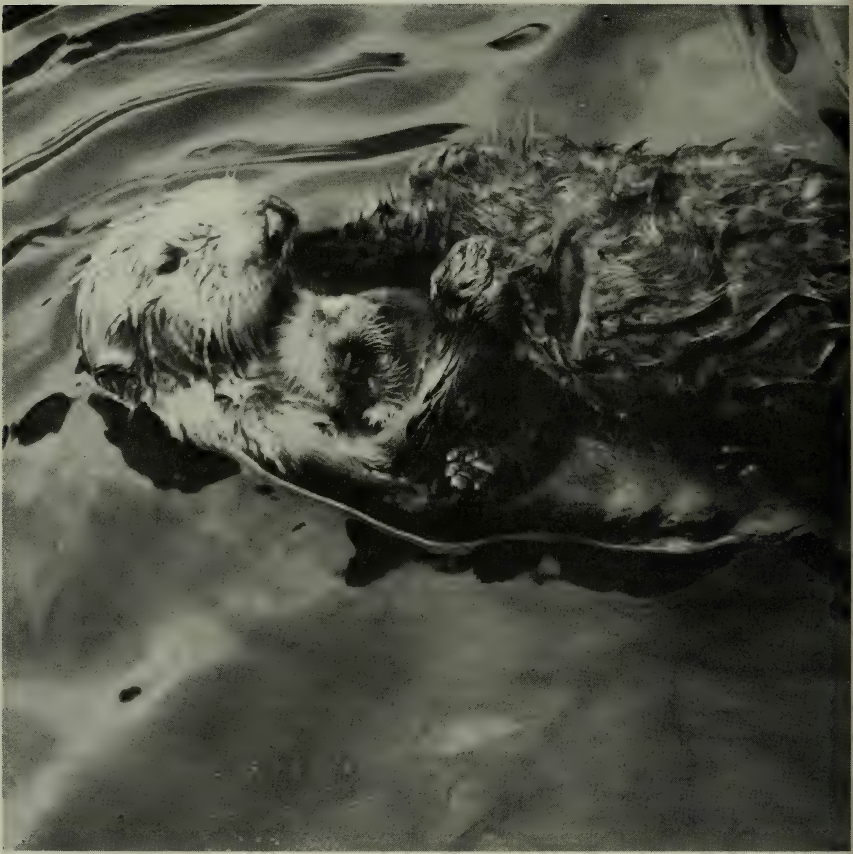


FIGURE 122.—The same female and pup as shown in figure 121 about 10 minutes after the mother had received an injection of Sparine tranquilizer. Although the mother appeared drowsy, she carried the pup on her chest and groomed its fur, not as thoroughly, however, as she normally should have. She also ate, and nursed her pup. After recovering from the effects of the tranquilizer, the mother remained tame and satisfactorily cared for her pup. (KWK 57–29–28)

no harmful side effects. I have used the drug on only two sea otters. It was my general impression that the animals did not regain normal alertness as soon as those given Sparine and gave inadequate attention to feeding and pelage care.

Piperazine citrate

This vermifuge was administered as a precautionary measure to captive sea otters by injecting an aqueous solution into fish before feeding. Before fish were frozen routinely prior to feeding, captives became heavily infested with *Terranova decipiens*. The effectiveness of the vermifuge was difficult to evaluate but it had no ill effect on the sea otters.

Vitamins

Because certain fish contain thiaminase, an enzyme that inhibits the proper utilization of vitamin B (Lee, 1948), thiamine hydrochloride was administered as a prophylactic measure. Pills containing vitamin B complex imbedded in the flesh of fish are readily eaten by otters and are administered daily to otters held permanently in captivity.

Antibiotics

Infections in paws, particularly the front paws, occurred when captive animals apparently scratched or cut these members during capture or in cages. An adult male with a badly infected front paw was given 600,000 units of Benzathine penicillin G "Bicillin" (Wyeth) and the infection disappeared after about 4 days. Two weeks later, however, the paw again began to swell and an additional dose of 600,000 units of Bicillin was administered and the infection disappeared permanently. The life of this animal, as well as those of several additional otherwise healthy animals, were probably saved through the injection of either Crystalline potassium penicillin G "Penicillin" (Wyeth) or Bicillin.

Pentobarbital sodium 3.7 gr. in each cc., isopropyl alcohol 10.5 percent, propylone glycol 10.5 percent, "Lethol" (Haver-Lockhart)

This drug administered intramuscularly was used to kill otters that were captured in nets and for various reasons were needed as specimens. The manufacturer recommended a dose of 1 cc. for every 5 lb. of body weight, but the sea otter was easily affected and we found that a dose of 10 cc. would kill large adults. The immediate effect is similar to other tranquilizers. Death followed injection in about 8 to 10 minutes.

Transportation of Captives

During transit from one location to another, the difficulty of controlling environmental temperatures and of furnishing sufficient bathing water causes severe complications. The longer the period in transit the more critical these factors become.

Sea otters have been transported in automobiles, aircraft, and ships. After many failures, knowledge is now available to assure successful transportation, provided that control of critical conditions is possible.

AUTOMOBILE

Otters were transported only short distances by truck or automobile. They were taken from the place of capture on Amchitka to field headquarters and later between holding facilities and ships or aircraft. Because the trips were short, the animals were conveyed in small carrying cages and no complications were encountered. However, they appeared disturbed, and whined or "whistled" en route. The longest automobile ride, 40 miles, was in 1965 when an adult male, "Gus," was taken from a dock in Seattle to the Tacoma Aquarium at Point Defiance. This animal appeared quite contented throughout the trip.

AIRCRAFT

On several occasions the only air transportation available was that of commercial passenger planes. Here, because of passenger needs, it was not possible to maintain temperatures low enough for sea otters. Distressed otters whined, whistled, and sometimes screamed, and attempted to escape from their cages by tearing at the wire screen cage with their teeth and forepaws. When available, ice was placed in the cages and cold water from bottles was poured on the otters. This they drank eagerly and rubbed into their fur. This treatment did not satisfactorily solve the problem, but several otters survived trips from Seattle to Washington, D.C. in 1954 and from Amchitka to Seattle in 1955 and 1956. The only otters that survived trips on heated, passenger-carrying aircraft were given constant attention, ice, and water during the trip. Of 19 otters taken at Amchitka and carried on commercial, passenger-carrying aircraft, 6 survived to reach Seattle. Of these, only two ultimately recovered from the trip. The time en route was from 36 hours to more than 4 days, and it appeared that few animals could tolerate such prolonged periods of stress.

To avoid self-injury and reduce excitement during air transports, K. L. Binkley, D.V.M., decided to administer a tranquilizer immediately before shipment from Amchitka on 2 November 1957. He wrote:

> This was done . . . and the animals shipped. Unfortunately, fatal complications developed when the tranquil animals were exposed to 11,000 feet altitude in a nonpressurized plane. Although it is not known for sure, apparently the drug causes a lowering in metabolism, and also in the animal's

> bility to compensate for oxygen lack. Some action of the drug might also nvolve lung tissue permeability. During this attempt to ship 5 otters to the oo in Seattle, the 4 adult otters were all administered 2 mg. Sparine per ound of body weight. A young 5-week-old pup was also included, although ittle hope was held for its safe arrival. In 2½ hours the pup was dead—robably from fright and altitude. In 15 more minutes the next youngest tter died, and in 5½ hours from take-off, the 3d otter (mother of the pup) uccumbed. The two remaining otters died shortly after arrival in Anchorage, laska—or approximately 15 hours from Amchitka. Post mortem findings can e found in "Causes of Death in Captivity."
>
> In the past, otters have been shipped in the same plane at the same altitude vith no apparent [in flight] ill effects—although they did die during [delays n] shipment or shortly thereafter from other reasons. The only additional actor in this case was the tranquilizer, and until more work is done with he drug, the use of it under similar circumstances would not be indicated.

The above is from a report of 7 November 1957, by Kenneth L. Binkley, D.V.M., of the Woodland Park Zoo, Seattle, who was temporarily attached to the Sea Otter Project at Amchitka Island from 1 October to 2 November 1957.

After the unfortunate experience described by Binkley, it was decided to make one more transport of otters aboard a commercial passenger aircraft, it being the only available transportation.

In December of 1957 this attempt was made by taking eight otters via Reeve Aleutian Airways from Amchitka to St. Paul Island, Pribilof Islands reservation. No tranquilizer drugs were given. The animals were in excellent condition when they departed Amchitka on the morning of 11 December. A storm, however, caused delay, and unsatisfactory conditions inherent in an unpressurized, heated (to 75° F.), passenger-carrying aircraft caused rapid deterioration and resulted in the death of six animals on the night of 11 December. It appeared that overheating was the primary cause of death. The Pribilofs could not be reached, so two surviving males were taken to Seattle. One, an old adult, failed to recover from the trip and died on 16 December. The other, a young adult, recovered from the trip but subsequently died of unknown causes on 22 September 1958.

No further effort was made to carry sea otters on passenger-carrying commercial aircraft. In 1959, however, a U.S. Fish and Wildlife Service aircraft was available for the specific purpose of transporting sea otters. On 20 May seven otters, each about 1 year old, were placed on the R4D (DC–3) aircraft at Amchitka. On the direct flight of 3.4 hours to St. Paul Island the cabin temperature was maintained at 48° to 49° F., and the maximum altitude attained was 2,000 feet. En route the animals exhibited mild distress but when water from a bottle was poured in their mouths and sprinkled on their fur, they became quiet. It appeared that even at the relatively low cabin temperature they suffered from heat distress when their fur was dry. All arrived at St. Paul Island in excellent condition.

Traveling cages with false wire bottoms were used during all experiments in aerial transportation to reduce fur soiling to a minimum. On the short trip from Amchitka to St. Paul the fur remained clean because the animals were not fed en route. On trips of longer duration (15 to 36 hours) fur soiling could not be avoided. Although body wastes fell through the false cage bottoms, the animals habitually lay on their backs to eat (fig. 123). Fish scraps and slime then accumulated in the fur with resultant loss of waterproof condition.

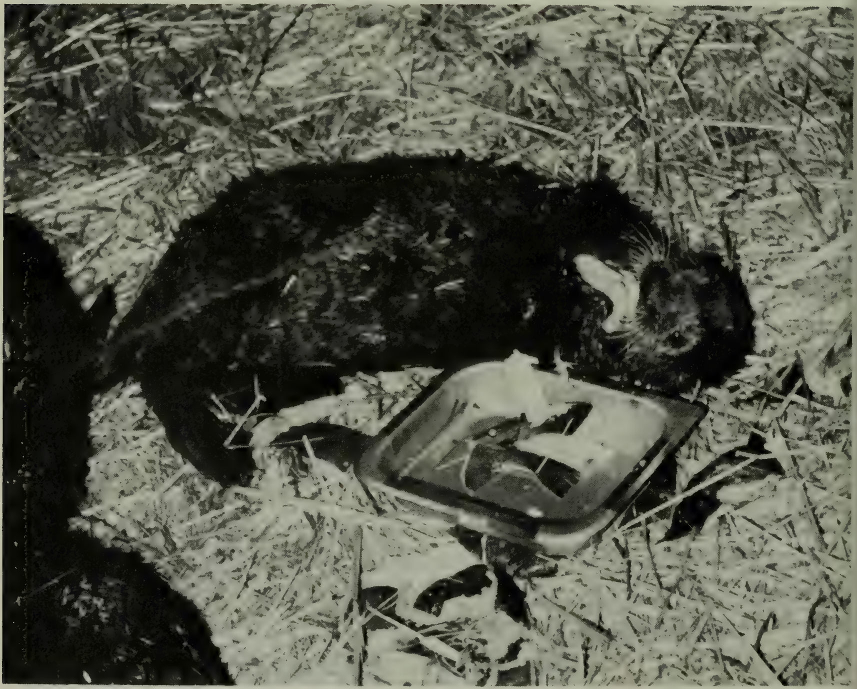


FIGURE 123.—Captive otters held on dry bedding habitually lay on their back or side. Fish scraps and slime thus fell into the fur while the animals ate. When the otters groomed and rubbed the fur with their paws, it became saturated with filth and particles of bedding material, and its waterproof quality was destroyed. When this animal was placed in water it did not float in the normal manner but sank because the air in its fur was lost. In this condition animals placed in cold water quickly chill and die. (KWK 55–5–1)

SHIP

Otters were carried aboard ship in two ways: (1) in cages with bedding and no water for bathing, and (2) in a cage which included a tank of constantly flowing sea water. Using the first method, when straw bedding could be changed frequently and conditions were such that the animals remained dry and did not chill, they remained in satisfactory condition. The three otters brought successfully from Adak to Seattle aboard a large ship in June of 1954 by R. D. Jones were well protected from the weather. The animals, however, required constant attention and when placed in a Seattle zoo pool the fur became wet to the skin, causing the animals to shiver. In another experiment (April 1955), frigid weather caused chilling and high mortality among the soiled animals resulted.

An experiment to test the second method was conducted in November-December 1965. A young adult male and an aged female were captured on 7 November at Amchitka and placed aboard the MV *Commander*. Their cage included a tank having a flow of about 50 gallons of water per minute. Between capture and arrival at Seattle on 3 December frequent storms were encountered. The female, probably near death when captured, refused to eat and died on 13 November. The male "Gus" survived the 3,000-mile trip and arrived in excellent condition.

It was demonstrated that: (1) sea otters may be transported without food and in small cages aboard unheated aircraft for several hours and arrive at their destination in excellent condition. Delays en route and overheating, however, may result in high mortality. (2) Aboard ship is a satisfactory method of transporting otters over great distances if a pool with an ample flow of clean water is available. (3) For short distances (up to 40 miles, at least) transportation by automobile is satisfactory.

Transplant Attempts

The idea of transplanting sea otters from areas of abundance to unpopulated parts of their former range, from which they were extirpated in the 19th century, has long been popular. Since 1950, six attempts to transplant otters were undertaken, the first five by the U.S. Fish and Wildlife Service and the sixth by the Alaska Department of Fish and Game. A brief resume of these attempts is presented below. Additional information concerning them is given under "Environmental Needs of Captives" and "Transportation of Captives."

A late-winter, early-spring attempt, 1951, to transplant sea otters by ship failed because of insufficient knowledge of the otters' needs in captivity. The 35 animals that were captured on Amchitka Island all died there before any were placed aboard the waiting ship.

Studies of captive otters were conducted in the winter of 1954 on Amchitka and were reported by Kirkpatrick et al. (1955) and Stullken and Kirkpatrick (1955). The knowledge gained through these studies was useful but did not assure survival of captives while awaiting transfer or while in transit to a new location.

Nevertheless, a transplant of 31 otters captured on Amchitka was attempted between 28 March and 4 April 1955. These otters were carried from Amchitka to the Pribilof Islands in cages with bedding of straw aboard the chartered fishing vessel *Paragon.* During the trip their fur became matted with filth, and when the 19 survivors were liberated each animal left a dirty brown trail in the water. Three of these were recaptured by hand within a few minutes of release. They were soaked to the skin, rigid with cold, and near death. None of the animals liberated was subsequently seen at the Pribilofs, and it is reasonably certain that none survived.

In early spring, 1956, Refuge Manager R. D. Jones, with Navy assistance, captured five otters at Amchitka and took them via ship 240 miles to Attu in the Near Islands. Jones told me that the pelage of these animals when they were released was in the usual soiled condition of animals held in dry bedding. No evidence is available to demonstrate whether or not any of these otters survived.

Because these experiences demonstrated the need for a short period of time in transit, the next experimental transplant was an attempt to take otters from Amchitka to the Pribilofs by air 11 December 1957. As described under "Transportation of Captives" none of the eight otters taken aboard a commercial, passenger-carrying airliner at Amchitka reached their destination.

The next experimental aerial transplant was undertaken in 1959 when an aircraft could be devoted exclusively to this undertaking. From 6 to 8 May, during a severe storm, 10 subadult otters were captured and placed in the pool enclosure. Three animals, in weakened condition when captured, soon died. Furthermore, the Amchitka pool was too small for 10 otters. Unless the animals were healthy when captured, their chance of survival was reduced by crowding and competition for food. Therefore, when animals died they were not replaced.

On 20 May, seven otters, including four females and three males, were taken to St. Paul Island by direct flight (see Transportation of Captives, Aircraft). They weighed 26 to 36 lb. and were estimated to be 1 to 1½ years old. They were marked with numbered monel tags on the hind flippers. The animals were liberated at Polovina Point within 20 minutes after landing. All appeared in excellent condition and, except for one, each accepted and ate a fish as it swam from shore. When liberated, the animals scattered.

On 21 May, D. L. Spencer and I watched one otter for some time from the cliffs of Reef Rookery (3 miles from the point of release). This animal was eating a large sea urchin and appeared contented and in good health. A brief aerial survey of a part of the west and south sides of St. Paul was made after takeoff on 21 May. Two additional otters were seen at this time; however, several thousand fur seals in the area made it difficult to distinguish otters.

Subsequent reports indicate that this transplant was partially successful in that the animals survived for a substantial period after liberation. Several observations of them were reported during the remainder of 1959 and in 1960. The last authentic sighting of one otter was by an experienced hunter, Maxim Buterin, in the spring of 1961. He saw it near the same place on two occasions.

Why these transplanted animals did not ultimately survive and reproduce is problematical. Two possible explanations may be considered: (1) Seven immature otters may be too small a nucleus to form a reproducing colony. Before they matured (estimated 2 to 3 years after liberation) too few survived natural attrition to form a colony. (2) The Pribilofs are at the northern limit of the species original range. Hardship caused by winter ice, as described by Nikolaev (1965) might be expected to have caused mortality.

In August 1965, John Vania and Edward Klinkhart, of the Alaska Department of Game, captured 41 and held 35 otters in a floating netted enclosure supported by a wooden frame and styrofoam floats in Constantine Harbor at Hinchinbrook Island in Prince William Sound, Alaska. Free circulation of water and a plentiful supply of food assured excellent survival in the holding facilities. The animals were transported 450 miles in a Grumman Goose Amphibian aircraft after receiving injections of a tranquilizer "Tranvet." During the 3.7-hour flight distress caused by overheating occurred. This problem of overheating was solved by constructing a container for water into the cages but 12 otters died in flight prior to the pen modification. On the last flight, after the cages had been modified, seven otters were transported. All lived and were released in what appeared to be excellent condition. In all, 23 otters survived to be liberated on the west coast of Chichagof Island in Southeastern Alaska. Subsequent reports of sightings indicate that at least some of these animals survived the winter of 1965-66. Further transplants were conducted in 1966 and more are planned.

The knowledge and techniques are now available to hold captive otters in excellent health and to transport and liberate them in condition to survive. Large juveniles weighing about 24 to 35 lb. (11 to 16 kg.), approximately a year or somewhat older, are most adaptable to life in captivity and are hardy and more adjustable to stresses of travel than are older animals. Also, they are of a convenient size to handle. Before being transported in small carrying cages, animals should be held in a satisfactory enclosure for an adjustment period of a week or more.

It is yet to be shown that transplanted otters will form colonies and repopulate vacant habitat. Southeastern Alaska offers hundreds of miles of coastline suitable for sea otters. Will the transplanted otters behave like certain other mammals and scatter after release and therefore fail to form breeding aggregations? Might they also behave like other mammals and seek to return to the home territory where they were captured? These questions can be answered only by continued experimentation.

MANAGEMENT

Management of sea otters depends on knowledge of population size and trend. This knowledge may not become available until a cropping program has been in operation for several years. A tentative management program can, however, be set on the basis of present knowledge.

In the case of the sea otter, incomplete knowledge of population dynamics factors dictates that a flexible management program be initiated. This should be closely coordinated with a continuing program of studies of reproduction, mortality, maturation, aging, optimum population size, movements, and habitat status. Quantitatively these factors will vary in different habitats and according to population density, food availability, etc.

If a wildlife resource is to produce a maximum sustained annual yield, mortality from all causes must not exceed recruitment at an optimum population level. At the present stage of our knowledge of sea otter biology, the following recommendations for a management program appear relevant:

(1) To attain knowledge of the population level of maximum sustainable yield, a relatively isolated study population should be chosen (Amchitka is a possible choice). (2) At the chosen location a sustained annual harvest should be taken without regard to economic yield. (3) Annual population surveys (preferably aerial) should be conducted where harvests take place. (4) Late winter and spring mortality should be monitored. (5) All female reproductive tracts, with carefully gathered field data, should be analyzed. (6) During harvesting operations animals of a size most desired by the fur market should be taken without regard to sex (the sex of an otter in the field is difficult to recognize) except that all females accompanied by young should be spared. (7) If it becomes evident that a kill predominating in males is desired, harvesting operations should be concentrated at or near known male concentration areas.

While a regular annual crop of otters is being taken from the chosen study population, otters should also be taken in other areas where they are now known to be abundant. These areas are (1) the Shumagin Islands, (2) the Bering Sea off Unimak Island and the tip of the Alaska Peninsula, (3) the Sanak Island–Sandman Reefs area, (4) the western Andreanof Islands (including the Delarofs), and (5) the western Rat Islands.

ESTIMATED YIELD

If a harvest is taken from any population annually, the kill should probably be limited initially to about 2.5 percent of the total population (both sexes and all ages older than dependent young).

The total Alaska fur seal population is about 1,200,000 animals, including an annual production of about 350,000 young (Roppel, Johnson, Anas, and Chapman, 1966). The young constitute about 30 percent of the population. In the sea otter it was indicated (see Reproduction in the Female) that 2 years normally elapse between births and that the annual mean number of young in the population is about 14 percent, or approximately one-half that in the fur seal in which 1 year normally elapses between births. It has been found during many years of cropping the fur seal that, on a sustained yield basis, about 5 to 6 percent of the total population may be cropped annually. Under this management system the fur seal herd grew from a population of about 215,000 seals in 1911 to about one and a half million in the late 1940's (Kenyon, Scheffer, and Chapman, 1954) and between 1911 and 1963 yielded 2,761,170 skins (Roppel and Davey, 1965).

Thus, until further experience is gained, it may be concluded that about 2½ to 3 percent of the total sea otter population may be cropped annually on a sustained yield basis.

Further studies of reproduction and of the effect of cropping on populations may modify this preliminary estimate. In spite of the indication that a female sea otter may bear no more than one young in each 2-year interval, it is possible that because maternal care is intensive and prolonged the survival rate of young in a sea otter population might exceed that in the fur seal population.

CLOSED AREAS

Many observations indicate that before sea otters move from a populated area to adjacent vacant habitat, a large local population is formed (see Distribution and Numbers). They apparently move as a result of overutilization of food resources by a crowded population. It follows that if vacant habitat is to be repopulated, large local populations should be allowed to form to create the "population pressure" necessary to cause significant emigration. Thus, it is my opinion that the "spearhead" of population expansion should not be disturbed if nearby but vacant habitat is to be repopulated.

HABITAT STUDIES

Studies of abundance of food species should be undertaken where sea otters are abundant and where they are sparse. It has been observed in several areas that sea otters are capable of overutilizing food resources. In a heavily utilized area, for example Amchitka, underwater exclosures large enough for a diver to enter could be established to evaluate the status of food organisms during a long period in exploited and unexploited areas. During the Amchitka study period (1955–63), it appeared that a large sea otter population was at that time overexploiting its habitat. Body weights of otters were less than those of otters from sparse populations, and the pelage of Amchitka otters appeared "poor" compared to that of otters from a sparse population. Under the condition of a depleted habitat, population manipulation may be necessary for a period of years before habitat recovery occurs and animals having optimum body size and pelage are produced.

TRANSPLANT STUDIES

Capturing, holding, and transporting sea otters is complicated and expensive. The results of experimental transplants are not yet evaluated. Why the transplant of seven healthy, subadult otters to St. Paul Island, Alaska, apparently failed ultimately to survive, in spite of survival after the animals were released, is not known (see Transplant Attempts). Repeated observations of the small Samalga-Umnak population indicate that a small isolated population grows slowly. Studies and transplant experiments undertaken by the State of Alaska and now in progress should yield valuable information. It appears probable that in certain areas and when a significant number of otters may be moved, transplanting may prove to be a valuable management device.

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Appendix 1

FIELD STUDIES OF SEA OTTERS, 1954–66

From 1949 to 1954, Refuge Manager R. D. Jones, Jr., reported ea otter observations. In the winter of 1950–51 he attempted a ea otter transplant. Dr. Robert Rausch and others of the U.S. Public Health Service studied and reported on the helminth paraites of the sea otter. These studies and the reports of other bservers are reviewed elsewhere in this report. The purpose of his chronological list is to record the field activities of the U.S. Fish and Wildlife Service under the sea otter study program which actually began in 1954 but was not formally begun until 1955. Appendix 2 summarizes material gathered from 1955 through 965.

Aleut laborers who participated in various phases of sea otter ield work include the late Fred Bezezekoff (Nikolski), Anton Bezezekoff (Nikolski), John Nevzeroff (Atka), Innokenty Golodoff Atka), and David Zaochni (Atka).

The expeditions listed below include a cumulative time of more han 2 years and 9 months of field work.

954

0 *February to 4 April.* Aleutian Islands. At Amchitka Island, field studies of sea otters. (D. Hooper, R. D. Jones, C. M. Kirkpatrick, C. J. Lensink, D. E. Stullken, and F. Wilke.)

955

5–17 *March.* Shumagin Islands. Observe sea otters at Simeonof, Little Koniuji, and Herendeen Islands. Transportation aboard M V *Paragon* (Kenyon, Lensink, and Wilke).

7 *March to 4 April.* Aleutian Islands. At Amchitka Island capture and hold sea otters for transplant. (Jones, Kenyon, Lensink, and Wilke.)

–10 *April.* Transplant attempt. Liberate sea otters at Otter Island, Pribilof Islands.

4–15 *April.* Shumagin Islands. Attempt to capture sea otters at Simeonof Island. (Kenyon and Wilke.)

26 July to 5 October. Aleutian Islands. At Amchitka Island observe sea otters; experiments with methods of holding otters in captivity and obtaining a food supply for them. (Kenyon.)

10 October. Seattle, Wash. Place two sea otters in Woodland Park Zoo.

1956

5 May to 26 July. Aleutian Islands. At Amchitka Island, field studies of sea otters and further experiments with feeding and holding in captivity. (Kenyon and Lensink.)

30 July. Seattle, Wash. Place two sea otters in Woodland Park Zoo.

1957

6 May to 28 September. Alaska survey. From Kodiak Island to Adak Island, field studies of population size and distribution of sea otters were conducted using boats and aircraft. (C. J. Lensink remained in the field during the entire period. R. D. Jones, R. Lopp, D. L. Spencer, W. Troyer, and Wilke participated with him in different areas.)

1 October to 11 December. Aleutian Islands. Amchitka Island, field studies of otters and further experiments in captive care and feeding of otters. (K. L. Binkley, Kenyon, and H. R. Krear.)

14 December. Seattle, Wash. Place two sea otters in Woodland Park Zoo.

1958

10–21 March. California. Search for sea otters in coastal areas and at Santa Rosa and San Miguel Islands of the Channel Islands group aboard the M/V *Trinity.* (W. J. Barmore and Kenyon.)

1959

14–21 January. Aleutian Islands. Adak Island. Conduct two experimental aerial surveys of sea otters using U.S. Navy UF–1 aircraft. Flight time: 5.6 hours. (Kenyon.)

21 January to 20 May. Aleutian Islands. At Amchitka Island, field studies of sea otters and experiments with otters in captivity were conducted. (Kenyon.)

19 May. Aleutian Islands. Aerial survey of sea otters from Attu to Amchitka Island using DC–3 aircraft. Flight time: 9.1 hours. (Kenyon, T. Smith, D. L. Spencer, and J. Tilford.)

20 May. Pribilof Islands transplant. Fly seven sea otters to St. Paul Island in a DC–3 aircraft and liberate them there. Flight time: 4.3 hours.

21 May. St. Paul Island. Observations of liberated otters.

21–28 May. Aleutian Islands. Aerial survey of sea otters from Semisopochnoi Island eastward to Herbert Island in the Islands of Four Mountains, inclusive, using a DC–3 aircraft. Flight time: 19 hours. Total flight time entire operation: 56.8 hours. (Kenyon, Smith, Spencer, and Tilford.)

13 July. Washington State. Aerial reconnaissance of coastal waters along outer coast of the Olympic Peninsula using a U.S. Coast Guard UF–2 aircraft. Flight time: 3 hours. (G. Eddy, Kenyon, F. Richardson, and V. B. Scheffer.)

14–18 July. Washington State. Boat survey of rocks and islets off the outer coast of the Olympic Peninsula. (Eddy, Kenyon, Richardson, and Scheffer.)

1960

2–5 March. Aleutian Islands. Aerial surveys of sea otters from the Islands of Four Mountains to the Sandman Reefs inclusive, using a DC–3 aircraft. Total flight time: 21.3 hours. (Kenyon, D. W. Rice, Smith, and Spencer.)

30 May to 13 July. Island surveys (surface only) in Alaska. Field studies of sea otters at Simeonof, Little Koniuji, Herendeen, and Nagai in the Shumagin Islands; at Caton and Sanak Islands; at Tigalda Island and in the waters off Unimak Island in the Aleutian Islands, and at Amak Island; transportation between islands was furnished by the M/V *Windward.* (C. H. Fiscus, Kenyon, and the late T. O'Brien.)

1961

3 July to 1 August. Commander Islands. Field observations of sea otters at the Soviet controlled islands of Medny and Bering; transportation aboard the USSR ships *Orel* and *Steregushti* and the U.S. FWS vessel *Penguin II.* (Kenyon, K. Niggol, A. Y. Roppel, and Wilke.)

21 October to 5 November. Aleutian Islands. An attempt to harvest and study sea otters in the outer Aleutians was negated when a U.S. Navy UF–2 aircraft carrying the field party crashed on 27 October at Adak Island during an aerial survey. (L. W. Croxton and Kenyon, and D. Cisney, killed in crash.)

1962

14 January to 4 April. Aleutian Islands. At Amchitka Island conduct field observations of sea otters and collect specimens from State of Alaska kill of 150 sea otters. (Croxton, Jones, and Kenyon.)

29 March and 5–10 April. Aerial surveys in Alaska. Aerial survey of sea otters in the Aleutian Islands from Kiska Island to Amak Island; the Sanak Islands; Sandman Reefs; Shumagin Islands; and areas along the south coast of the Alaska Peninsula to Kuliak Point. Total flight time: 53.6 hours. (J. J. Burns, Kenyon, J. S. Kobza, Smith, and Spencer.)

8–11 September. Washington State. Investigate reports of possible sea otter sightings along the outer coast of the Olympic Peninsula. (Kenyon.)

26–29 October. Alaska State biologists kill 24 sea otters on Amchitka. (Croxton and E. Klinkhart.)

27–28 October. Washington State. Investigate reports of possible sea otter sightings in the San Juan Islands of Puget Sound aboard the M/V *Trinity.* (Kenyon, Rice, and Scheffer.)

1963

4 March to 13 April. Aleutian Islands. At Amchitka Island collect specimens from 303 sea otters taken by State of Alaska biologists. (J. E. Burdick, E. Klinkhart, and J. Vania.)

1–22 July. Aleutian Islands. Field observations of sea otters at Adak Island and Buldir Island in the outer Aleutian Islands. Transportation from Adak to Buldir aboard USCGC *Clover*, return on USCGC *Klamath.* (V. D. Berns, E. L. Boeker, Jones, Kenyon, A. E. Peden, and M. Zhan.)

31 July to 3 August. Aleutian Islands. At Amchitka Island 20 sea otters were taken by State of Alaska biologists and specimens furnished to the Bureau of Sport Fisheries and Wildlife (E. Klinkhart and J. Vania).

1964

In Seattle working on 1963 specimens and analyzing accumulated field data.

1965

23 January to 10 February. Field observations of coastal and island areas of Baja California, Mexico to examine sea otter habitat and search for possible surviving animals. (D. W. Rice, D. Lluch B., and Kenyon.)

18 April to 9 May. Aerial survey of sea otters in the Aleutian Islands, Cold Bay to Attu Island. (E. Klinkhart, D. L. Spencer, T. A. Smith, J. King, and Kenyon.)

23 October to 9 November. At Amchitka Island. Monitor effects of AEC-DOD Long Shot nuclear blast. Aerial surveys and surface observations. (E. Klinkhart, D. L. Spencer, T. A. Smith, R. Tremblay, and Kenyon.)

9 November to 3 December. Transport male sea otter (Gus) aboard M/V *Commander* from Amchitka to Seattle. (Kenyon, Capt. Cliff Andersen.)

1966

Work in Seattle on specimens and accumulated data.

Appendix 2

TABULAR SUMMARY OF SEA OTTERS STUDIED, 1955 THROUGH 1965

Every otter for which any record was kept is included in this table; for some of them the data were inadequate and they are not included in other sections of this report.

Place and time	Number obtained—			Number tagged and released			Number held captive		Skins taken [2]		Total otters studied			
	BD [1]	Shot	Net or club [2]	♂	♀	Sex?	♂	♀	ADFG	FWS	♂	♀	Sex?	All
Amchitka Island:														
Mar-Apr 1955	15	—	31	—	—	—	9	19	—	1	20	23	3	46
Aug-Sept 1955	5	—	6	—	—	—	4	2	—	—	4	2	5	11
May-July 1956	58	5	30	5	4	—	10	11	—	7	44	29	20	93
Oct-Dec 1957	31	—	23	2	—	—	10	11	—	12	24	13	17	54
Jan-May 1959	84	—	125	34	52	—	7	7	—	46	104	94	11	209
Various areas: [3]														
June-July 1960	7	14	—	—	—	—	—	—	—	11	10	8	3	21
Amchitka Island:														
Feb-Apr 1962	107	154	122	43	77	—	—	—	155	6	141	234	8	383
October 1962 [4]	3	24	—	—	—	—	—	—	24	—	6	19	2	27
Mar-Apr 1963 [5]	42	285	13	4	2	1	—	—	303	3	126	199	15	340
Aug-Sept 1963	—	20	—	—	—	—	—	—	20	—	1	19	—	20
Nov. 7, 1965	—	—	2	—	—	—	1	1	—	—	1	1	—	2
Total	352	502	352	88	135	1	41	51	502	86	481	641	84	1,206

[1] BD = beach dead, i.e., remains of sea otters found on beaches; 41 of the remains listed were so fragmentary that no use was made of them.

[2] Most of these were netted on beaches; several were clubbed in 1962 and 1963 during the Alaska Department of Fish and Game cropping operations in which the U.S. Fish and Wildlife Service (FWS) cooperated.

[3] Specimens were collected in the Shumagin and Sanak Islands and in the Bering Sea off the north coast of Unimak Island.

[4] Specimens and data collected by L. W. Croxton and E. Klinkhart, Alaska Department of Fish and Game.

[5] Specimens and data collected by J. E. Burdick.

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Many geographic locations (islands, points, passes, etc.) mentioned in the text are omitted from the index. They may be found in the text under the island groups (Andreanof Islands, Fox Islands, etc.) or adjacent geographic areas (such as Alaska Peninsula), which are included in the index. In general, scientific names of organisms are omitted from the index but are included in the text. An attempt was made to avoid repeating in the index what may be found in the table of contents.

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OF THE
SWAINSON'S WARBLER

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NUMBER 69

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE

NORTH AMERICAN FAUNA

This publication series includes monographs and other reports of scientific investigations relating to birds, mammals, reptiles, and amphibians, for professional readers. It is a continuation by the Bureau of Sport Fisheries and Wildlife of the series begun in 1889 by the Division of Ornithology and Mammalogy (Department of Agriculture) and continued by succeeding bureaus—Biological Survey and Fish and Wildlife Service. The Bureau distributes these reports to official agencies, to libraries, and to researchers in fields related to the Bureau's work; additional copies may usually be purchased from the Division of Public Documents, U.S. Government Printing Office.

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NATURAL HISTORY
OF THE
SWAINSON'S WARBLER

by Brooke Meanley, *Wildlife Biologist*

Patuxent Wildlife Research Center
Division of Wildlife Research
BUREAU OF SPORT FISHERIES AND WILDLIFE

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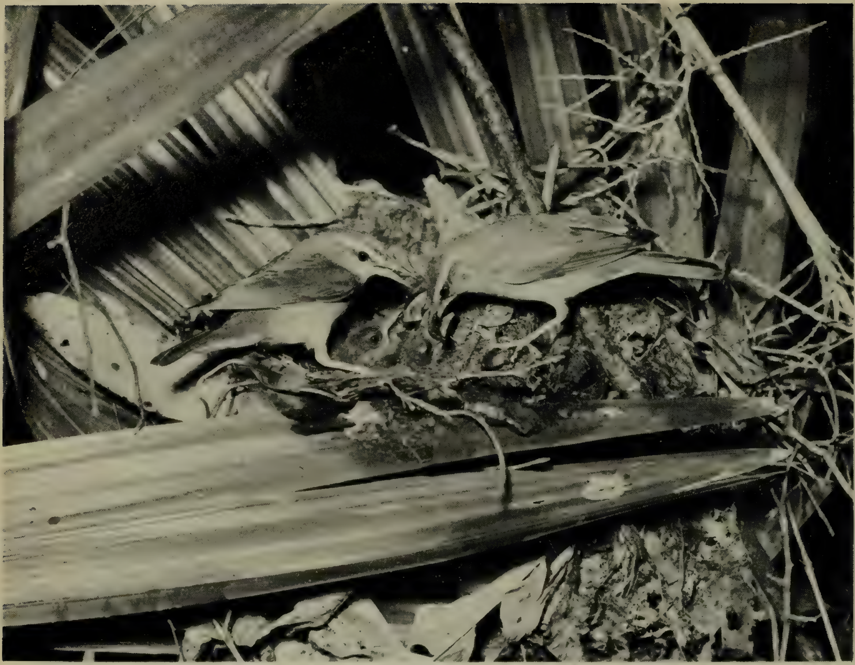

A pair of Swainson's Warblers at their nest near Jacksonville, Fla. (Photograph by Samuel A. Grimes).

Introduction

The Swainson's Warbler *(Limnothlypis swainsonii)* is one of the least known of songbirds in the southern United States and one that is widely sought by bird enthusiasts. It is unusually appealing to the student of birds because it is hard to find, because its forbidding habitat is challenging, and because it is associated with the Audubon-Bachman period of North American ornithology.

The difficulty of becoming well acquainted with the Swainson's Warbler has been noted by a number of field ornithologists. In the Alabama River bottoms, Arthur H. Howell of the U.S. Biological Survey reported (1928, p. 284–285) it as confined to the deep swamps and riverbottom woods where canebrakes occur, and remarked that its secretive habits conceal it from all but the most persistent observers. In the big swamps above Mobile in May 1911, July 1913, and May 1914 he heard at least nine of these warblers, but because of the impenetrable vegetation was unable to collect any.

Maurice G. Brooks, Professor of Wildlife Management at West Virginia University, and his coworker W. C. Legg (Brooks and Legg, 1942, p. 81) found this elusive warbler extremely difficult to observe in the dense shadows of the "rhododendron hells" of the Alleghenies:

> With their neutral brown coloration, their rapid movements, and their apparent liking for the centers of the thickets, they seemed to blend imperceptibly into their surroundings.

While the remarks of Sprunt and Chamberlain (1949, p. 435) are generally true—that "Swainson's Warbler remains today one of the few land birds really difficult to find and study"—there are times when it can be observed at closer range than almost any other songbird. It is not a very suspicious bird. It seems hard to find chiefly because of the character of its habitat.

The bird student seeking this species in a briery-viny entanglement or canebrake disrupts the peaceful atmosphere of the bird's home, naturally frightening it. Or perhaps it is the never-ending wall of nearly impenetrable vegetation between the observer and the bird that discourages one. But in some habitats, when the birds are on breeding territories, and especially during the courtship and preincubation periods when the pair are traveling together, they can often be approached to within 5 feet and kept under observation at close range for many minutes. Several times during its preincubation period, one paired bird fed within 2 feet of my eyes as I lay prone on the ground. I found canebrakes to be the best habitat for sustained observations: the visual conditions are generally uniform, and the birds tend to stay away from the densest part of the canebrake.

Although the Swainson's Warbler is not as abundant as some of the other southern warblers, in 1968 I knew of at least two areas in which I could find 50 individuals in a single day. One of these was the Great Dismal Swamp in southeastern Virginia; the other was the Ocmulgee River floodplain forest, 3 to 5 miles southeast of Macon, Ga., where I first became acquainted with the Swainson's Warbler (Meanley, 1945, p. 395–401). When stationed at Camp Wheeler near Macon, 1944–46, I began making observations in the extensive riverbottom canebrakes, and I returned to this area for further study in 1963 and each spring thereafter through 1968. During these 24 years the habitat and number of individuals remained virtually unchanged.

When living at Alexandria, La., in 1956 and 1957, I made observations in Bayou Boeuf Swamp, at the edge of that central Louisiana city. In Arkansas in 1967 I obtained information on territorial and nesting behavior in the batture (land between the levee and the river), between the mouth of Bayou Meto and Pendleton Ferry, along the Arkansas River. Mountain habitats near the City of Charleston and in Nicholas County, W. Va., were visited during the spring of 1965 and 1966. In 1966 I began observations in the Great Dismal Swamp, a few miles south of Norfolk, Va. This continues to be my main study area.

METHODS

Habitats in breeding territories were analyzed in several ways. Plant species composition was determined by sampling ¼-acre plots. In canebrake and scrub palmetto *(Sabal minor)* habitats, the density and number of stems were determined by sampling 10-foot-square quadrats.

The light-shading effect of the combined canopy, lower tree, and shrub strata was determined in ¼-acre plots of several tracts. A 2-foot-diameter hoop divided into eight equal sections was held directly overhead, and 20 random readings were made, sighting upward. Readings were taken between 11:30 a.m. and

2:30 p.m. on sunny, windless days. To measure the light inensity, I placed a mirror on the ground in the exact spot where a wainson's Warbler had been feeding less than 1 minute before, eld an exposure meter 1 foot above the mirror with the photolectric cell upward, and took a reading.

Territory-mapping and transect methods were used in making ensuses. Dimensions of territories were determined by spotapping males on maps marked off into transects or grids. Studes of territorial behavior were facilitated by color-marking birds f both sexes with celluloid or metal leg bands. Birds were capured with mist nets for marking.

Birds taken on the breeding and wintering grounds were eighed shortly after capture; birds taken during migration were eighed after being held in a freezer for various periods of time.

Measurements are from files in the U.S. National Museum. ime is given as Eastern Standard Time unless otherwise indiated. Bird names used in the text are from the A.O.U. Check-list f North American Birds (1957) ; plant names are from Fernald 1950) and Radford, Ahles, and Bell (1964) ; and insect names re from Lutz (1935).

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I am grateful to many persons for their contributions to this roject. Anna Gilkeson Meanley, my wife, worked with me on everal occasions in the Ocmulgee riverbottom canebrakes and in he Great Dismal Swamp. Linda Hall, Lucille F. Stickel, Nancy . Coon, Paul A. Stewart, and Van T. Harris reviewed the manucript. Samuel A. Grimes gave me a copy of his superb photograph f a pair of Swainson's Warblers at their nest, and Frederick C. chmid made several excellent photographs for me. Oliver H. ewitt of Cornell University presented me with a photograph of ohn Abbott, and E. Milby Burton of the Charleston Museum gave e permission to use a photograph of the Reverend John Bachan. The Fogg Art Museum of Harvard University and the arvard College Library made available a copy of John Abbot's llustration of the Swainson's Warbler. H. L. Stoddard, Sr., and obert A. Norris of the Tall Timbers Research Station, Tallaassee, Fla., gave me specimens that struck the TV tower at the tation. Eugene P. Odum and William Dopson of the University f Georgia and James B. Cope of Earlham College gave me data rom specimens in their collections. J. Fred Denton of Augusta, a., and M. G. Vaiden of Rosedale, Miss., provided me with imortant data from their studies. John W. Aldrich, Gorman M.

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History

The Swainson's Warbler was described by Audubon from specimens collected by John Bachman (fig. 1) on the banks of the Edisto River in South Carolina in 1832 or 1833. Audubon named

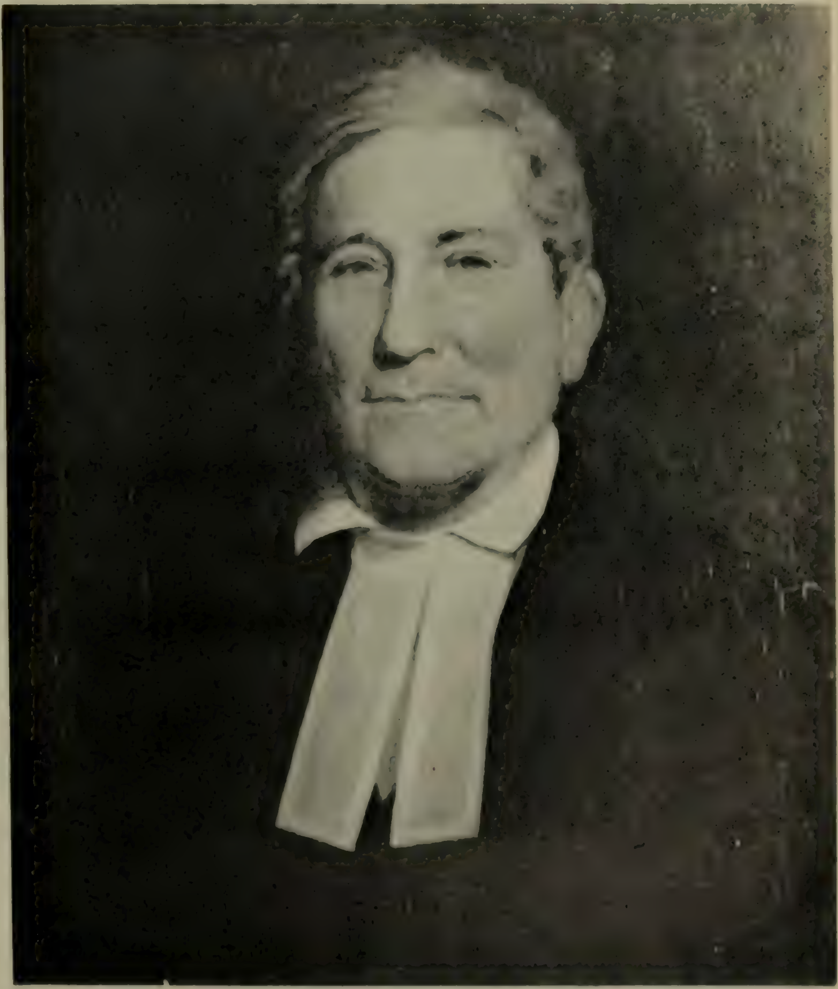

FIGURE 1.—The Reverend John Bachman. He collected the type specimen of the Swainson's Warbler along the banks of the Edisto River in South Carolina in 1832 or 1833. Photograph courtesy Charleston (S.C.) Museum.

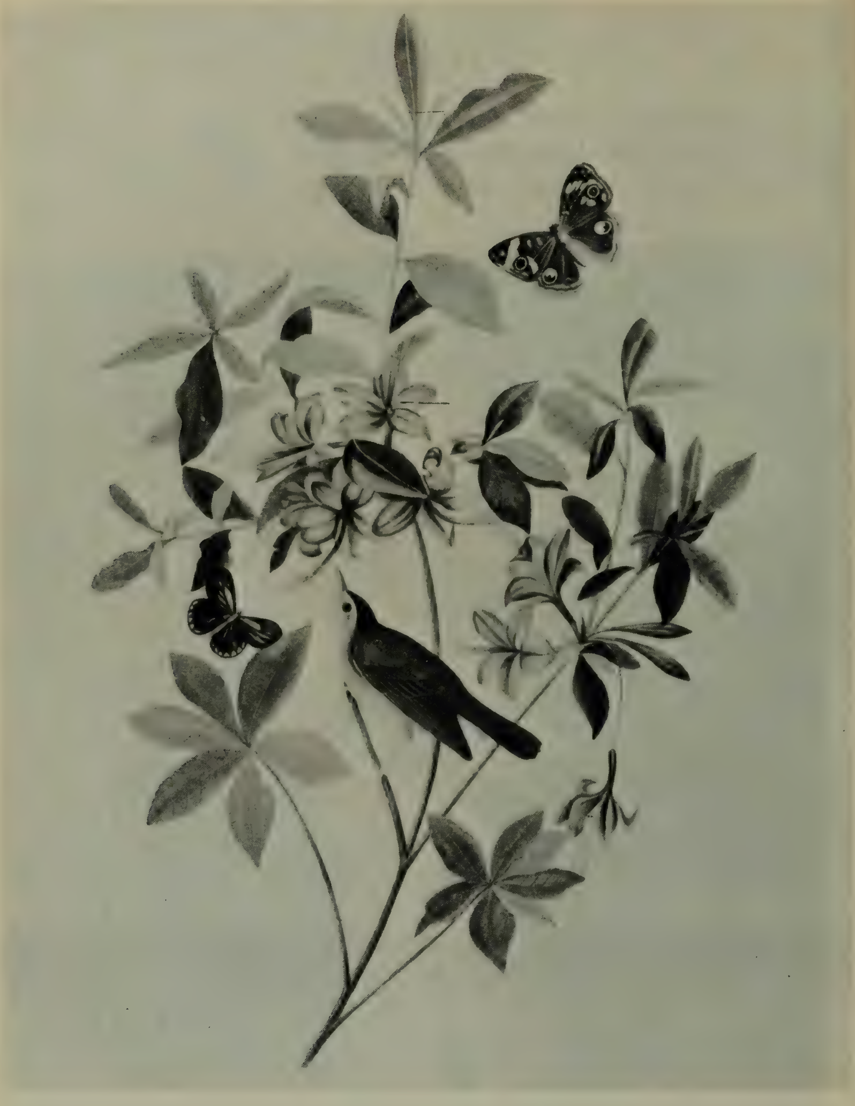

FIGURE. 2.—Audubon's painting of the Swainson's Warbler, from Bachman's type specimen.

the new bird for his friend the English ornithologist William Swainson, giving it the scientific name *Sylvia Swainsonii.*[1] Audubon's painting of the new warbler (fig. 2) appeared in his *Birds of America* (1834a, plate 198). The description appeared in his

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[1] The present generic name, *Limnothlypis,* meaning marsh finch, is credited to Stone (1914, p. 26).

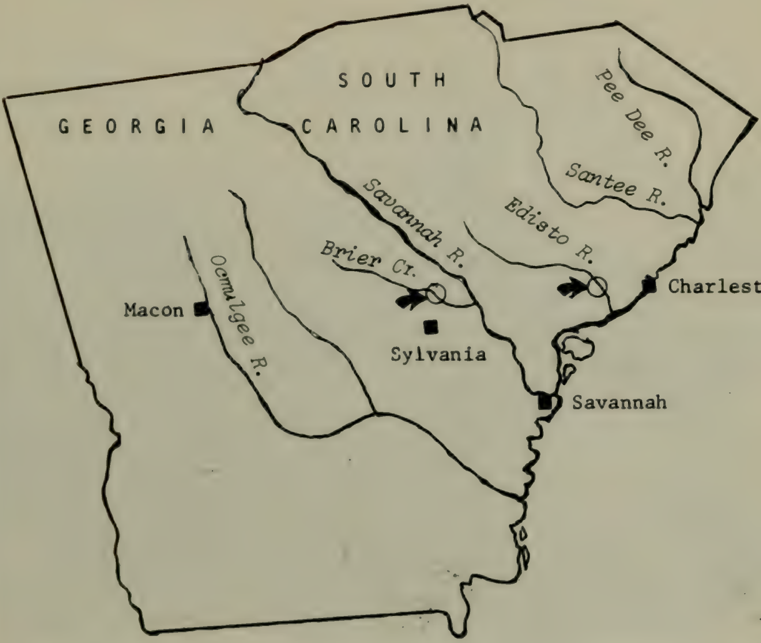

Figure 3.—The arrow-designated circle in South Carolina marks Bachman's type locality; that in Georgia marks the approximate locality where Abbot collected specimens some 25 years before Bachman.

Ornithological Biography (Audubon, 1834b, p. 564–565). The type specimen was given to the U.S. National Museum by Spencer F. Baird, one-time Secretary of the Smithsonian Institution, who acquired it from Audubon.

The discovery of this new species by Bachman, some 25 miles south of Charleston, is described as follows (in Audubon 1834b, p. 564):

> I was first attracted by the novelty of its notes, four or five in number, repeated at intervals of five or six minutes apart. These notes were loud, clear, and more like a whistle than a song. They resembled the sounds of some extraordinary ventriloquist in such a degree, that I supposed the bird much farther from me than it really was; for after some trouble caused by these fictitious notes, I perceived it near me and soon shot it.

Bachman collected five specimens in the spring of 1832 or 1833. The type locality apparently is in the vicinity of Jacksonboro and Parker's Ferry Landing, S.C. (figs. 3 and 4). Audubon reported

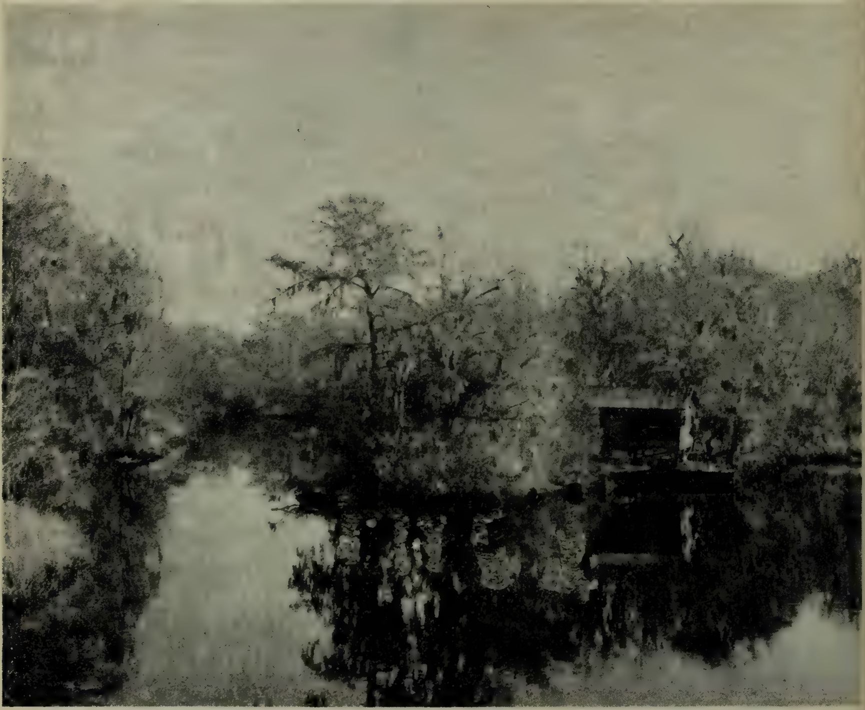

FIGURE 4.—The Edisto River near Jacksonboro in South Carolina, where Bachman collected the type specimen of the Swainson's Warbler.

that the type specimen was collected in 1832, the year that he was on an expedition to Labrador. However, Arthur T. Wayne (1906, p. 227), Charleston ornithologist of the late 1800's and early 1900's, pointed out that since Audubon was in Labrador in 1833 and not 1832 the type specimen must have been collected in 1833.

While John Bachman gets the credit for the discovery of the Swainson's Warbler, John Abbot (fig. 5), a Georgia naturalist, apparently collected a specimen some 25 years earlier but made no public record of the event. However, he made an identifiable portrait of the bird (fig. 6). Many of Abbot's Georgia bird paintings were deposited in the British Museum and the Boston Society of Natural History. Those, including the Swainson's Warbler, deposited in the latter place now repose in the Fogg Art Museum, Harvard University. Walter Faxon (1896, p. 207), one of the first persons to study Abbot's paintings, made the following remarks about the painting of the Swainson's Warbler:

> On looking through the Abbot bird-portraits several arrest the eye from their historic interest. Plate 68 is a good representation of Swainson's War-

bler, drawn at least a quarter of a century before this species was described and named by Audubon. On the reverse of the plate is the following autograph note by Abbot: L. 6. May 8. Swamp.—Swamp Worm-eater.

FIGURE 5.—John Abbot (self portrait), Georgia naturalist who collected a specimen of the Swainson's Warbler about 25 years earlier than Bachman, but did not report it. His painting of the bird was discovered many years later. Photograph courtesy Oliver H. Hewitt, Cornell University.

During his first years in Georgia after the Revolutionary War, Abbot lived in the town of Jacksonboro in Screven County. Jacksonboro, no longer in existence, was located in the Savannah River valley near Sylvania. Abbot did much of his collecting in a swamp along Brier Creek (fig. 7), a tributary of the Savannah.

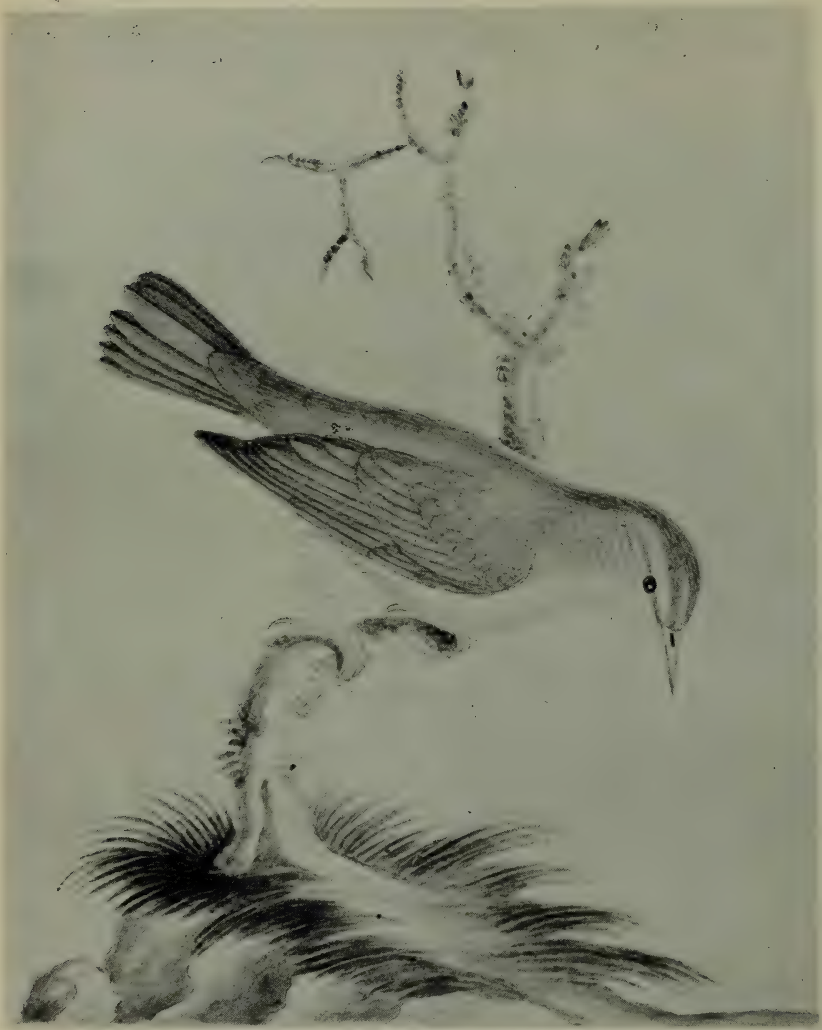

FIGURE 6.—Photograph of John Abbot's painting of the Swainson's Warbler, which he called the "Swamp Worm-eater." Illustration courtesy Fogg Art Museum, Harvard University, and the Harvard College Library.

After Bachman collected his historic five specimens in 1832 or 1833, the Swainson's Warbler was almost a lost species for the next 50 years. According to William Brewster (1885a, p. 66). only eight or nine specimens were collected during that period. Then in 1884, Brewster and Arthur T. Wayne made significant collections and studies in the vicinity of Charleston, S.C. (Brewster, 1885a). Wayne reported the first nest and eggs known to science (Brewster 1885b, p. 468), near Charleston on June 6, 1885. Troup D. Perry (1886, p. 188) of Savannah, Ga., found a nest 22 days earlier (May 16) but did not report his discovery as soon as did Wayne.

Since the Swainson's Warbler was thought to be restricted to the Coastal Plain, ornithologists were surprised to learn by the 1930's that this warbler was a locally common breeding bird to an elevation of about 3,000 feet in the Southern Appalachians. Before the 1930's there had been several records from the Piedmont suggesting the possibility of an up-country population. L. M. Loomis (1887, p. 347–348) found the bird at Chester, S.C., 150 miles from the coast, and W. H. LaPrade, Jr., (1922, p. 88–89) found a nest with eggs at Atlanta, Ga., 1,050 feet above sea level in the foothills of the Appalachians.

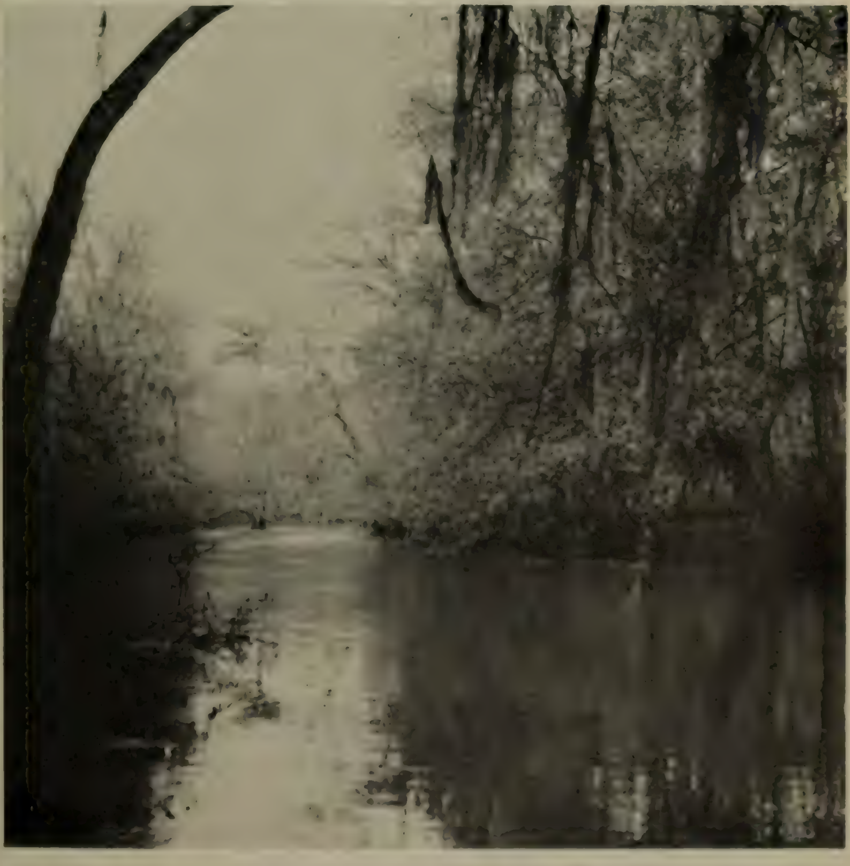

FIGURE 7.—Approximate location on Brier Creek, Screven County, Ga., where Abbot collected the "Swamp Worm-eater."

The first record of this species in the Appalachians is apparently based on a specimen collected on June 14, 1924, by P. C. Bibbee (see Brooks and Legg, 1942, p. 76) in West Virginia. The bird was taken at Buzzard's Rocks, Monongalia County, in what Brooks and Legg describe as "a rugged region of hemlock-and-rhododendron-clad mountains only a few miles from the Pennsylvania border."

Additional early records from the Appalachians are those of T. D. Burleigh, who collected three specimens near Asheville, N.C., on September 17, 1930, August 31, 1931, and September 14, 1932, (in U.S. National Museum collection) and those of E. A. Williams (1935, p. 458–459) who sighted several birds near Tryon, N.C., on May 8, 1934. The Swainson's Warbler was established as a breeding bird of the Appalachians in the summer of 1932 when F. M. Jones discovered several nests in southwestern Virginia near Bristol (Murray, 1939, p. 9).

Distribution

BREEDING RANGE

The Swainson's Warbler spends nearly 6 months of the year in the United States (fig. 8). During this period the bird is primarily associated with the river floodplain forests and swamps of the South Atlantic and Gulf Coastal Plains, and with the rich moist woods of the Mixed Mesophytic forest (see Braun, 1950, p. 39–49) of the Southern Appalachians. The mountain habitats are in the hemlock-rhododendron *(Tsuga canadensis–Rhododendron maximum)* association and the cove hardwoods forest. Apparently the Piedmont Province is generally unsuitable for occupation by this species. While there are scattered records of its occurrence in the Piedmont Province during the breeding season, there appear to be no breeding concentrations in this in-between area. The swamps and floodplain forests of the Coastal Plain, and sections of the Mixed Mesophytic forest where this species occurs in the mountains, are more humid than most of the forests of the Piedmont.

During the summer the climatic features of the two major physiographic regions occupied by the Swainson's Warbler are somewhat similar. Blair (1942, p. 130, 132) has classified the climate of the South Atlantic and Gulf Coastal Plains as Humid Subtropical type, and the climate of the Southern Appalachians as Humid Continental type (warm long summer subtype). The Humid Subtropical climatic type has a moderate-to-heavy rainfall at all seasons, usually with a maximum in summer; 9 to 12 months with mean temperature above 50° F.; and a growing season of 220 days or more. The Humid Continental type (warm long summer subtype) has a rainfall between 20 and 40 inches with a summer maximum; 6 to 9 months with mean temperature above 50° F.; and a growing season of 140 to 220 days.

Atlantic Coastal Plain

Along the Atlantic Coastal Plain the Swainson's Warbler occurs from extreme southern Delaware to southeastern Virginia and southward and inland as far as the fall line to about Jacksonville and the Suwannee River in Florida.

The northern limit on the Atlantic coast is the Pocomoke River Swamp in Sussex County, Del., and Worcester County, Md. The Pocomoke Swamp lies about 10 miles inland from the Atlantic

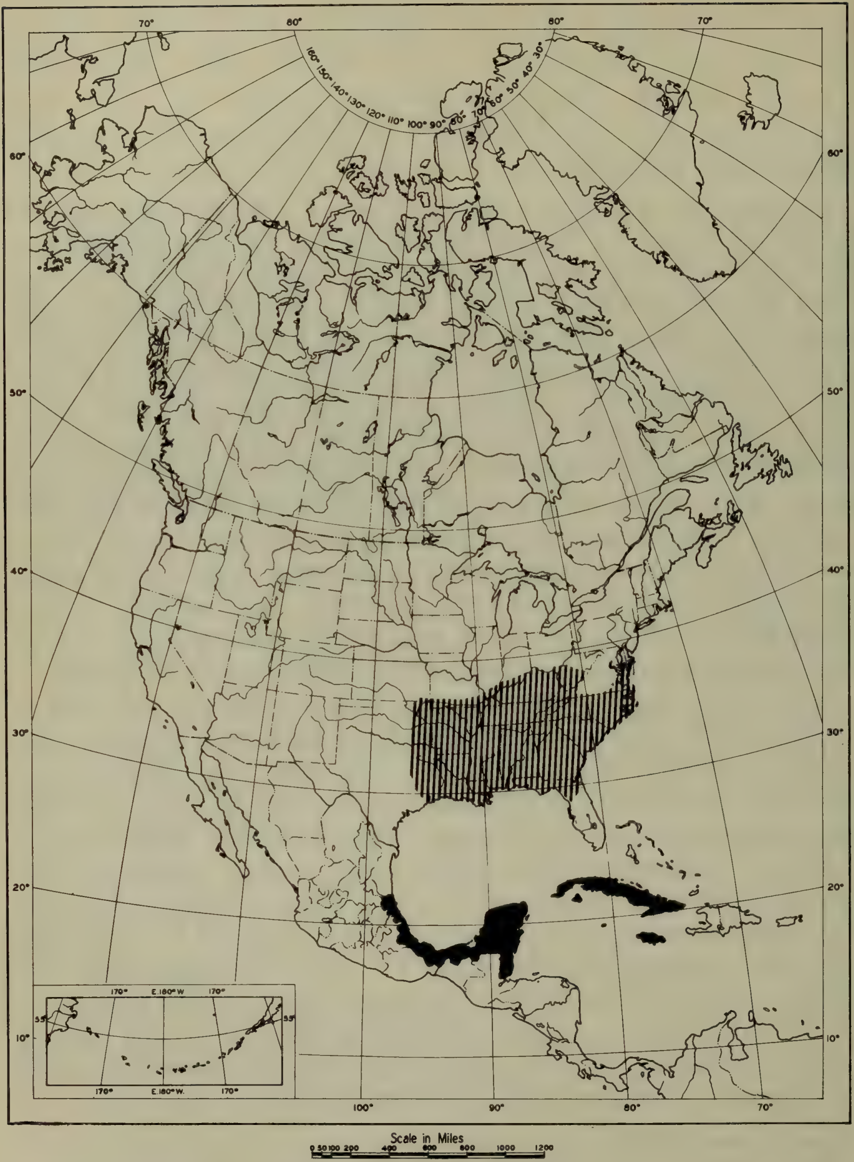

FIGURE 8.—Distribution of the Swainson's Warbler. Hatched area indicates general limits of breeding range; solid black area indicates general limits of winter range.

Ocean and extends from just above the Delaware-Maryland line southward nearly to the Virginia boundary. Only a few scattered pairs nest in this cypress-gum disjunct swamp.

The Swainson's Warbler is locally common in the Great Dismal Swamp in southeastern Virginia and northeastern North Carolina, and in certain floodplain forests just below the fall line. In many of these river floodplains its distribution coincides with that of the giant cane *(Arundinaria gigantea)*. It was also reported to be common in the 1960's in the Ocmulgee River floodplain forest, 3 to 5 miles south of Macon, Bibb County, Ga.; in the Savannah River Valley, from Augusta, Richmond County, Ga., downstream about 25 miles; and in the Wateree River Swamp, northwest Sumter County, S.C. Scattered pairs and singing males have been reported from many other areas in the Carolinas and Georgia.

The distributional status of the Swainson's Warbler in the lower Coastal Plain of South Carolina and Georgia has apparently changed in the last 50 years. In the *Living Bird,* Fifth Annual, (Meanley, 1966, p. 152), I made the following comments regarding the former abundance of this species in the lower Coastal Plain of the Southeast:

> At the close of the 19th century and the beginning of the 20th, Swainson's Warblers were apparently more numerous in the lower Coastal Plain than they are today. Wayne (1910:149-150) found them to be common breeding birds near Charleston, South Carolina, as did Perry (1887:142) near Savannah, Georgia. During the period of 22 April to 25 September 1884, Wayne collected 47 specimens of this species near Charleston. Considering modes of travel available to Wayne and the limited area of his operations, his collecting of so many specimens would seem to indicate a sizable population in the area. Perry (1887) reported 24 active nests near Savannah in the spring of 1887, which likewise suggests that Swainson's Warblers were more abundant in the late 19th century than at present. E. S. Dingle of Huger, South Carolina, who worked with Wayne and who bridged the gap between Wayne's time and the present, informed me in April 1958 that he had noted during his lifetime a marked downward trend of the population in the coastal area. A. Sprunt, Jr. (*in* Sprunt and Chamberlain, 1949:435), a protégé of Wayne's, has seen this warbler only four times in the lower Coastal Plain of South Carolina.
>
> In the lower Savannah River Valley, an area extending 30 miles upriver from Savannah, E. O. Mellinger and I found only scattered individuals and occasional pairs during the early 1960's—certainly not the numbers and concentrations found farther up the valley near Augusta, as reported by Murphey (1937:42), Norris (1963:47), and J. F. Denton (pers. commun.).

Gulf Coastal Plain

In the Gulf Coastal Plain the Swainson's Warbler occurs from north of the Suwannee River in northern Florida, northward and westward to southern Alabama, eastern Mississippi, and the lower Mississippi Valley as far as southern Illinois, and westward through southern Arkansas and the southeastern corner of Oklahoma to at least Brazos County, Tex.

During the mid-20th century, areas where it was reported as locally common were mostly in the lower Mississippi Valley. However, the lower Mississippi Valley was the center of the most intensive ornithological investigations during the period. It undoubtedly was common also in many areas east of the lower Mississippi Valley.

In northwestern Florida it was formerly reported as a locally common breeding bird along the Wacissa River near Waukeenah, along the Suwannee River near Old Town (Wayne, 1893, p. 338; 1895, p. 367), and along the Aucilla River (Howell, 1932, p. 386). F. M. Weston (1965, p. 105) regarded it as an uncommon summer resident at Pensacola.

In Alabama it is rather widely distributed, with breeding concentrations in the Alabama River bottoms above Mobile and in the vicinity of Bear Swamp a few miles west of Montgomery (Howell, 1928, p. 284; Imhof, 1962, p. 439).

In the Louisiana section of the lower Mississippi Valley, G. H. Lowery (personal communication, 1962) reported it as commonly breeding in the vicinity of Baton Rouge, and I found it locally common in 1956-57 in Bayou Boeuf Swamp near Alexandria as well as in the Tensas River area a few miles south of Tallulah.

In the Mississippi River Delta, at Rosedale, Bolivar County, Miss., M. G. Vaiden (personal communication, 1968) found nests and reported the species as fairly common in the batture along the Mississippi River.

In eastern Arkansas I found it locally common in the lower White River bottoms, in the East Moon Lake and Scrubgrass Bayou areas, and along the Arkansas River between the mouth of Bayou Meto and Pendleton Ferry. Five nests were located in the latter locality between 1966 and 1968.

Apparently the Swainson's Warbler was a breeding bird in the late 1800's and early 1900's in the St. Francis River "sunken lands" of southeastern Missouri and northeastern Arkansas, where it occurred in canebrakes with the Bachman's Warbler *(Vermivora bachmanii)* (Widmann, 1895, p. 115-117). Since the time of Widmann's investigations, much of the swampland in that area has been drained and the canebrakes destroyed.

At Memphis, Tenn., B. B. Coffey, Jr., (1941, p. 30–31) reported Swainson's Warblers nesting within the city limits and in at least

10 localities in surrounding Shelby County. These warblers occur regularly in most of the Coastal Plain riverbottoms of western Tennessee and in the Reelfoot Lake area. Mengel (1965, p. 389) reported the species as "fairly common locally in lowland forests of extreme western Kentucky (Fulton, Hickman, and Ballard Counties), rare and local in swamp forests of the Pennyroyal and Western Highlands."

The Gulf Coastal Plain extends as far northward as the southern tip of Illinois, a short distance above the confluence of the Ohio and Mississippi Rivers. Records from the Coastal Plain of southern Illinois are as follows: Olive Branch, Alexander County, May 15 and 20, 1909, and Reevesville, Johnson County, June 21–22, 1909 (Howell, 1910, p. 216); Cairo, Alexander County, September 1, 1938, female collected (Ammann, 1939, p. 185–186); and DuQuoin, Perry County, a few miles north of the Coastal Plain, June 7, 1907 (Gross, 1908, p. 225).

The breeding range of the Swainson's Warbler west of the Mississippi Valley is imperfectly known. It has been found during the breeding season as far west as Brazos County, Tex. (Purrington, 1966, p. 35); and in southeastern Oklahoma (McCurtain County) just beyond the Coastal Plain (Sutton, 1967, p. 491).

Southern Appalachians

The Swainson's Warbler breeds in the mountains in south-central West Virginia, perhaps southeastern Ohio, eastern Kentucky, southwestern Virginia, eastern Tennessee, western North and South Carolina, and northern Georgia and Alabama.

In West Virginia, Swainson's Warblers occur mostly on the Allegheny Plateau, west of the main Allegheny ridges. M. G. Brooks and W. C. Legg (1942, p. 78) found the species locally common near Mt. Lookout, Nicholas County, where elevations are between 2,200 feet and 1,300 feet at the Gauley River level. The three principal streams along which Swainson's Warblers were found are Gauley River; Collison Creek, a tributary of the Gauley; and Anglins Creek, a tributary of Meadow River.

The Swainson's Warbler breeds commonly in the mountain ravines opposite Charleston, W. Va., in the Kanawha River Valley. Charleston lies at an elevation of about 600 feet, and the birds are found from the city limits upward. Fifty miles west of Charleston, in the Ohio River Valley, there are records from Huntington, W. Va., (Seeber and Edeburn, 1952) and across the river at Chesapeake, Lawrence County, Ohio (Green, 1947, p. 211). M. G. Brooks (1965, p. 281) states that Swainson's Warblers are known from 14 West Virginia counties.

In the mountains of eastern Kentucky this warbler was first noted by G. H. Brieding (1944, p. 6–7) on Black Mountain, Harlan County, on July 5 and 6, 1944. R. M. Mengel (1965, p. 391) collected a specimen on June 26, 1951, near Elkhorn City, on the line between Dickinson County, Va., and Pike County, Ky. The elevation at this point is about 2,200 feet.

Farther south along the Appalachian chain in the Holston Mountains of southwestern Virginia and northeastern Tennessee, nesting has been recorded by F. M. Jones near Bristol, Washington County, Va. (Murray, 1939, p. 9). Three miles northeast of Shady Valley, Johnson County, Tenn., W. M. Perrygo and C. Lingebach collected an adult male at an elevation of 3,000 feet on June 8, 1937, and observed two others at 2,600 feet elevation 5 miles north of Shady Valley near Beaverdam Creek (specimen in U.S. National Museum).

In western North Carolina, T. D. Burleigh collected three specimens near Asheville, in the Pisgah National Forest, one each on September 17, 1930, August 31, 1931, and September 14, 1932 (specimens in U.S. National Museum). At Tryon, near the North Carolina–South Carolina border, E. A. Williams (1935, p. 458–459) observed a Swainson's Warbler on May 8, 1934, and the following year observed a pair from May 9 to 14.

An important concentration area of this species in the Southern Appalachians is where the States of North Carolina, South Carolina, and Georgia meet. H. M. Stevenson, Jr., (1941, p. 46) reported Swainson's Warblers from Highlands, Macon County, N.C., June 20, 1937, at 3,800 feet elevation, and July 3, 1937, at 3,700 feet elevation. J. F. Parnell and T. L. Quay (1964, p. 144) reported Swainson's Warbler "as a rather common summer resident" at Toxaway River Gorge, Transylvania County, N.C. In that area at an elevation of 1,400 feet Parnell observed an adult feeding young. R. H. Peake, Jr., (1965, p. 114) reported finding a bird near Cashiers, Jackson County, N.C., April 22, 1965.

In western South Carolina an adult male was taken by W. M. Perrygo at Walhalla, Oconee County, June 25, 1940. Also in Oconee County, J. B. Shuler (1962, p. 75–76) noted a singing male in the Sumter National Forest, May 19 and 30, 1962.

The first record in the mountains of Georgia was obtained June 3, 1948, by C. Neal and J. F. Denton (Denton, 1948, p. 24-25), at an elevation of 1,700 feet on Tray Mountain near Robertstown, White County. In the same locality, Denton and Neal (1951, p. 27–28) saw three males on May 8, 1949, and four males on May 9, 1950. At Clayton, Rabun County, Ga., E. O. Mellinger (personal communication) observed two pairs almost daily during April, May, and June 1968.

In Alabama, T. A. Imhof (1962, p. 439) recorded this species in the northeastern corner of the State (Long Island Gulf, Jackson County), at 1,150 feet, June 7, 1957.

Ozark Mountains

There are records of birds in two locations in the Arkansas Ozarks. D. A. and F. C. James and S. Hilty (1966, p. 577) recorded three territorial males 12 miles southeast of Yellville, Marion County, Ark., June 25, 1966. At Fayetteville, Washington County, in the northwestern corner of the State, the Jameses (1966, p. 518) observed a male on territory daily, May 4 to 31, 1966.

Westward beyond the Ozarks, the breeding range extends into the Prairie Plains physiographic region of northeastern Oklahoma. Nice (1931, p. 155) reported that A. J. Kirn located several nests along the Little Caney River near Copan, Washington County, in June 1914 and June 1917. This locality is only about 10 miles from the Kansas border. A more recent occurrence in the same county was reported at Bartlesville, April 23, by S. Veal (Williams, 1966, p. 524).

Piedmont province

The following are records made during the breeding season. Records from the Piedmont province before May and after July may represent either birds on their breeding grounds or migrants.

Virginia.—Charlottesville, in the upper Piedmont, in the foothills of the Blue Ridge Mountains: Summer 1913 (Ferneyhough, 1914, p. 291), and spring 1961 through 1964, by R. S. Merkel (Scott and Cutler, 1964, p. 442).

South Carolina.—Greenwood County, near the Savannah River Valley, approximately 40 miles above the fall line: July 3, 1924, nest (F. W. Hahn in Sprunt and Chamberlain, 1949, p. 436).

Georgia.—Atlanta, in the foothills at an elevation of about 1,200 feet: May 27, 1920, and May 30, 1922, nests (LaPrade, 1922, p. 88–89). Athens: May 20, 1921 (Burleigh, 1938, p. 24).

Kentucky.—Bullitt County: June 27, 1937 (Carpenter, 1937, p. 32).

Extralimital records (United States)

Records of occurrence beyond the limits of the normal breeding range are as follows: Kearney, Neb., April 9, 1905, by C. A. Black (Worthen, 1906, p. 227); Holly, Prowers County, Colo., May 12, 1913 (Lincoln, 1918, p. 236); Prospect Park, New York City, May 5, 1950, by Carleton and Helmuth (Bull, 1964, p. 362); Mt. Carmel, Wabash County, Ill., April 1878 (Ridgway, 1878, p. 163); Lake Quivira, Johnson County, Kans., May 11, 1957 (Hardy, 1957, p. 10); and Linwood, N.J., May 23, 1968 (Savell, 1968, p. 159).

WINTER RANGE

The main wintering grounds are the Caribbean archipelago in the general area of latitude 20° N., including Jamaica and Cuba, and the Yucatan Peninsula south to British Honduras (fig. 8).[2]

Cuba

Oriente Province.—Guantanamo: January 18, 1914, male collected (Ramsden, 1914, p. 253).

Las Villas Province.—Cienfuegos: December 23, 1948, through January 3, 1949, several specimens collected (Eaton, 1953, p. 169).

La Habana Province.—Havana: September 25, year ?, one specimen collected, and April 14, 1922, one specimen collected, both possibly migrants (from the distribution files of the Migratory Bird Populations Station of the Bureau of Sport Fisheries and Wildlife, at Laurel, Md.).

Jamaica

St. Thomas Parish.—Kingston: December 31, 1946, and February 5 and 7, 1947, 3 females collected; December 3, 1946, through February 7, 1947, 9 birds observed (Tordoff, 1952, p. 321). Port Royal Mountain: February 18, 1879, specimen collected by E. Newton (Merriam, 1885, p. 377).

St. Andrew Parish.—Hope: February 1879, specimen collected by E. Newton (Merriam, 1885, p. 377). Hermitage: April 8, 1879, specimen collected by E. Newton (Merriam, 1885, p. 377). Mt. Elizabeth: October 1 and 7, 1879, December 21, 1881, and March 16, 1882, specimens collected by E. Newton (Merriam 1885, p. 377).

Swan Islands

A specimen was collected on March 1, 1912 (Peters, 1913, p. 378). The Swan Islands are in the Caribbean Sea, between the Yucatan Peninsula and Jamaica, near latitude 18° N. and longitude 84° W.

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[2] There are several records for the Bahama Islands that probably represent migrants, and they are treated as such here.

Mexico

Quintana Roo.—Santa Lucia: January 24, 1912, specimen collected (Peters, 1913, p. 378). Chetumal: February 12, 1949, specimen collected (Paynter, 1955, p. 242). Cozumel, Cozumel Island: December 27, 1961, specimen collected by L. C. Binford (Louisiana State University collection).

Campeche.—Pacaytain: January 15, 1940, specimen collected (Traylor, 1941, p. 219).

Veracruz.—Veracruz: winter of 1887-88 (distribution files, Migratory Bird Populations Station).

British Honduras

February 20, 1956, specimen collected by S. M. Russell (Louisiana State University collection) in the Orange Walk District.

Migration

SPRING

Swainson's Warblers apparently follow the most direct routes in migrating from wintering to breeding grounds. From West Indian wintering grounds they apparently reach the United States by island-hopping to southern Florida. Birds moving northward from eastern Cuba and Jamaica may touch some of the Bahama islands and cays enroute: there are March and April records from Bimini, Andros Island, and Cay Lobos.

The northern coast of Yucatan is a natural departure point for trans-Gulf flight to the Gulf Coast of the United States. Studies by G. H. Lowery (1945, p. 92-121; 1946, p. 175-211) and H. M. Stevenson (1957, p. 39–77) and observations by several other ornithologists lend credence to a trans-Gulf movement of Swainson's Warblers from the northern coast of Yucatan and the shore of the Bay of Campeche. The distribution of casualties at the base of the Tall Timbers TV tower near Tallahassee, Fla., 50 miles from the Gulf, indicates that the spring flight through that region is mainly in a southwest-to-northeast direction (Stoddard and Norris, 1967, p. 11, 15). Stoddard and Norris believe that this is mainly a trans-Gulf flight, with a minor segment of the flight skirting the Gulf. The lesser migration, which they refer to as the "Florida Peninsula–West Indian Flight" comes through mainly on easterly, southeasterly, and southerly winds.

It is probable that some of the Swainson's Warblers that winter in eastern Mexico migrate around the Gulf, moving northward along the eastern coasts of Mexico and Texas. The numerous spring records from coastal Texas could represent both trans-Gulf and circum-Gulf migrants.

Exceptionally early arrivals reach Florida by the middle of or the third week of March. There are records by J. Johnson and D. R. Paulson for March 16 offshore near Eau Gallie and for March 19 at Goulds, south of Miami (Stevenson, 1960, p. 304), and Bush Key pond, Dry Tortugas, March 17, 1964 (Robertson and Mason, 1965, p. 136). The first wave of migrants reaches northern Florida during the last week in March. At Tallahassee, during the period 1956 to 1966, 14 of 83 birds striking the Tall

Timbers TV tower arrived in the last week of March (Stoddard and Norris, 1967, p. 71). The earliest arrival date at Tallahassee was March 21.

Earliest arrivals at other localities are as follows: New Orleans, La., one on March 30 and four on April 1 (Kopman, 1905, p. 292; and 1915, p. 186); Savannah, Ga., March 25 (Burleigh, 1958, p. 495); Macon, Ga., March 31 (B. Meanley, MS.); and noted by K. McCracken and E. Payne, Corpus Christi, Tex., March 28 (Webster, 1966, p. 531).

Average dates of first arrivals are: Baton Rouge, La., April 2 (Lowery, 1945, p. 107); Alexandria, La., April 3 (B. Meanley, MS.); Macon, Ga., April 3 (B. Meanley, MS.); Augusta, Ga., April 3 (J. F. Denton, Jr., personal communication); Suffolk, Va. (Dismal Swamp), April 15 (B. Meanley, MS.); Clayton, Ga. (mountains), April 17 (E. O. Mellinger, personal communication); Charleston, W. Va., April 15–17 (Sims and DeGarmo, 1948, p. 3); and Maryland-Delaware boundary (Pocomoke Swamp), April 21 (Meanley, 1950, p. 94).

The main flights at Tallahassee, Fla., for the period 1956 to 1966 were during the first and second weeks in April, when 50 of 83 birds that struck the Tall Timbers TV tower (Stoddard and Norris, 1967, p. 71) were reported to be this species. At Macon, Ga., from 1963 to 1968, the main flights were in the second week of April (B. Meanley, MS.). At Charleston, W. Va., the main flight was April 19 (Sims and DeGarmo, 1948, p. 3). At the Dismal Swamp in southeastern Virginia, the main flight was during the third week in April (B. Meanley, MS.).

FALL

During 3 years at Macon, Ga., and at Gillett, Ark., I made weekly observations from the time the local population arrived in the spring until it departed in the fall, and I found that most of the breeding population remained until about the middle of September. A. T. Wayne (1910, p. 150) reported that at Charleston, S.C., "The song period lasts from their arrival until September 15." E. Sims and W. R. DeGarmo (1948, p. 3) stated that at Charleston, W. Va., "singing males were heard briefly in early mornings as late as September 15."

Apparently the bulk of the birds migrate through the Deep South between the middle of September and the middle of October. At the Tall Timbers TV tower at Tallahassee, Fla., Stoddard and Norris (1967, p. 71) reported, 58 of 60 fall strikes of this species occurred between September 11 and October 10.

The earliest migrants reach the middle Gulf Coast by early

August and the Florida Keys by mid-August and early September. Migrants were reported at Gulfport, Miss., on August 8 and 19, and at Deer Island, Miss., on August 26 (Burleigh, 1945, p. 110); at Sombrero Key, Fla., on August 17 (Howell, 1932, p. 386); and at Dry Tortugas, Fla., by September 2–9 (Sprunt, 1951, p. 224).

Late records of departure are: Knoxville, Tenn., October 7 and 8 (Howell and Tanner, 1951, p. 62); Tybee Island, near Savannah, Ga., October 18 (distribution files, Migratory Bird Populations Station); Tallahassee, Fla., October 14 (Stoddard and Norris, 1967, p. 71); and Sombrero Key, Fla., November 8, 10, and 13 (Howell, 1932, p. 386).

The migration route to the wintering grounds is apparently the reverse of that to the breeding grounds. The distribution of casualties at the base of the Tall Timbers TV tower indicates that the heaviest flight is from northeast to southwest, the direction of trans-Gulf migration. Some birds that migrate through southern Florida also pass through the Tallahassee area in the fall (Stoddard and Norris, 1967, p. 71).

The coast of Georgia and the eastern coast of Florida are also a southward migration route, as evidenced by the following records: Tybee Island, Ga., September 23 and 24 and October 2 and 18 (Burleigh, 1958, p. 496); Jacksonville, Fla., October 5 and 7, 19 birds picked up at TV towers (Cunningham, 1965, p. 29); St. Augustine, Fla., September 14 (distribution files, Migratory Bird Populations Station); Miami, Fla., October 2 (L. A. Stimson, distribution files, Migratory Bird Populations Station); and Loxahatchee National Wildlife Refuge, Fla., October 6 (P. W. Sykes, Jr., personal communication).

Southward movement along the Gulf Coast in Texas and northern Mexico would be expected, but records are fewer for the fall than for the spring: Rockport, Tex., October 20 (C. H. Hagar, distribution files, Migratory Bird Populations Station); Kemak, Tex., September 27 (J. S. Heiser, distribution files, Migratory Bird Populations Station); and Matamoros, Tamaulipas, Mexico, just over the Texas border from Brownsville, August 29 (Phillips, 1911, p. 84).

Early arrival records in the West Indies are: Havana, Cuba, September 25 (Bent, 1953, p. 38); and Mt. Elizabeth, Jamaica, October 1 and 7 (Merriam, 1885, p. 377).

Ecological Relations

The optimum habitat of the Swainson's Warbler is a rich, damp (but not wet) woods with deep shade and moderately dense undergrowth. This combination occurs in the physiographic areas in which this species is nearly always found—namely, the floodplain and swamp forests of the Atlantic and Gulf Coastal Plains and certain plant associations of the mixed mesophytic forest of the Southern Appalachians. When in swamps, the Swainson's Warbler frequents those parts that usually are not inundated, but occasionally on the Coastal Plain it may be observed foraging along the wet margin of a swamp or in low wet spots that have been left from receding floodwaters in floodplain forests. In such situations, its foraging behavior on the ground may resemble that of the Louisiana Waterthrush *(Seiurus motacilla)*. Where inundation is present in a floodplain forest, it is usually the result of late spring floods or heavy rains, after the birds have selected a breeding territory in a dry section of woods.

Whether on the Coastal Plain or in the mountains, this species is usually near some major drainage system. The river valleys provide moist conditions on the breeding grounds, as well as "highways" for migration.

In Coastal Plain forests, where most of my experience has been, it is my observation that the Swainson's Warbler, more than its closest avian associates, is restricted to the shadier part of the forest. Species such as the Carolina Wren *(Thryothorus ludovicianus)*, the White-eyed Vireo *(Vireo griseus)*, the Prothonotary Warbler *(Protonotaria citrea)*, the Hooded Warbler *(Wilsonia citrina)*, the Kentucky Warbler *(Oporornis formosus)*, the Cardinal *(Richmondena cardinalis)*, and the Rufous-sided Towhee *(Pipilo erythrophthalmus)* spend only a part of their time in parts of the forest as shady as those frequented most of the time by the Swainson's Warbler. The deep shade of the Swainson's Warbler environment is the result of dense upper canopy, layer of lower trees, and shrub strata. Herbaceous ground cover is absent in most of the warbler's habitats, and where it occurs it is usually of little consequence as a shade producer.

The Swainson's Warbler lives mostly in the shrub stratum and on the ground. In many habitats, the shrub stratum, or undergrowth, is composed mainly of a single species such as giant cane in the floodplain forest, sweet pepperbush *(Clethra alnifolia)* in the swamp forest, scrub palmetto in the bottomland forest, and rhododendron *(Rhododendron maximum)* in the mixed mesophytic forest. The structure of the undergrowth may be remarkably uniform, as in some canebrakes, palmetto thickets, and sweet pepperbush stands.

COASTAL PLAIN

In the Coastal Plain Province, river floodplain forests and swamps are the principal physiographic types in which the Swainson's Warbler lives during the breeding season, or summer half of the year. Since the terms swamp, riverbottom, hardwood bottom, and floodplain forest are often used synonymously, an explanation of these terms seems appropriate. The lowland forest bordering a southern river is generally known to the forester or plant geographer as a riverbottom or bottomland. It is usually a complex of several forest communities, including swamps, floodplain forests (also known as hardwood bottoms), and riverfront hardwoods. Most swamps are permanently flooded except during droughts; they thus differ from floodplain forests which are periodically flooded, usually in late winter or spring. There are several types of swamps. Those in riverbottoms are known as river or alluvial swamps; they are found in the lowest part of the bottomland, either bordering the river or between the floodplain forest and adjacent uplands. Swamps found away from riverbottoms are known as nonalluvial or inland swamps; good examples are the Great Dismal and Okefenokee Swamps.

Recognized as subdivisions within the floodplain or bottomland forests of the lower Mississippi Valley are the first bottoms, and the ridge bottoms (or cane ridges). In low, poorly drained flats of the first bottoms, the Overcup Oak–Bitter Pecan *(Quercus lyrata–Carya aquatica)* type is predominant. The Sweetgum–Water Oak *(Liquidambar styraciflua–Quercus nigra)* type is found in the better drained parts of the first bottoms. Sweet Pecan *(Carya illinoensis)*, Sweetgum, and Southern Red Oak *(Quercus falcata)* are prominent on the cane ridges. These subdivisions are not as distinct or are non-existent in the South Atlantic coastal floodplain forests.

In floodplain and swamp forests, the main plant formations selected by the warbler are usually canebrakes (figs. 9–12), scrub palmetto, and sweet pepperbush. Greenbrier (*Smilax* spp.) is

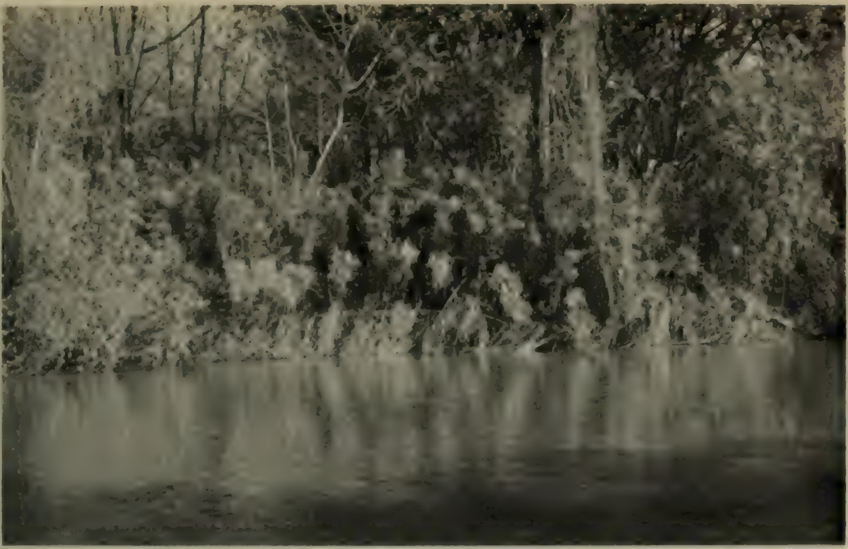

FIGURE 9.—Canebrake along the edge of the Ocmulgee River, about 3 miles south of Macon, Bibb County, Ga., 1968.

often associated with sweet pepperbush where the Swainson's Warbler is found.

The canebrake is the prime and classic habitat of the Swainson's Warbler on the Coastal Plain. This habitat has mostly disappeared, having been reclaimed for agriculture, or grazed, burned, or flooded out of existence. Canebrakes are restricted mostly to floodplain forests or hardwood bottoms. In the lower Mississippi River Valley they occur on first bottom ridges, which are well-drained areas; whereas on the South Atlantic Coastal Plain they occur along the river and stream edges in floodplain forests where there is little change in elevation from the river to the edge of the uplands. Thus, they are subject to partial inundation during periods when the bottomlands are flooded.

Scrub palmetto occurs in floodplain forests and swamps in the southern part of the Coastal Plain breeding range of the Swainson's Warbler. Sweet pepperbush is an important plant for the Swainson's Warbler in the northern part of its Atlantic Coastal Plain breeding range. This was the principal habitat in which I found it in the Great Dismal Swamp of southeastern Virginia and the Pocomoke Swamp on the Eastern Shore of Maryland. In some places, sweet pepperbush stalks have a somewhat canebrakelike aspect, the main stems growing fairly straight, with similar spacing or density and shade effect.

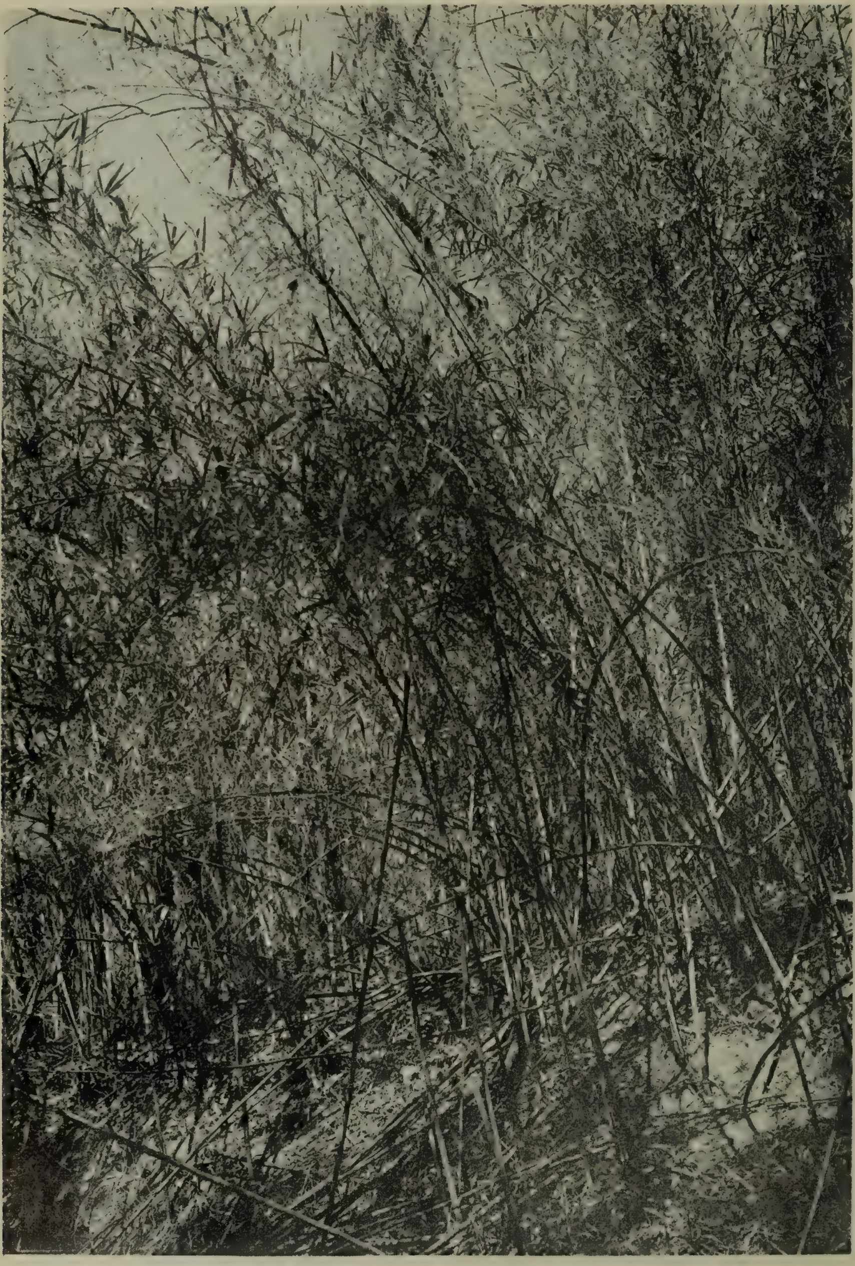

FIGURE 10.—Canebrake habitat in the Ocmulgee River floodplain forest near Macon, Ga. The longest poles are 30 feet in length. The diameter of the largest poles is 1¼ inches.

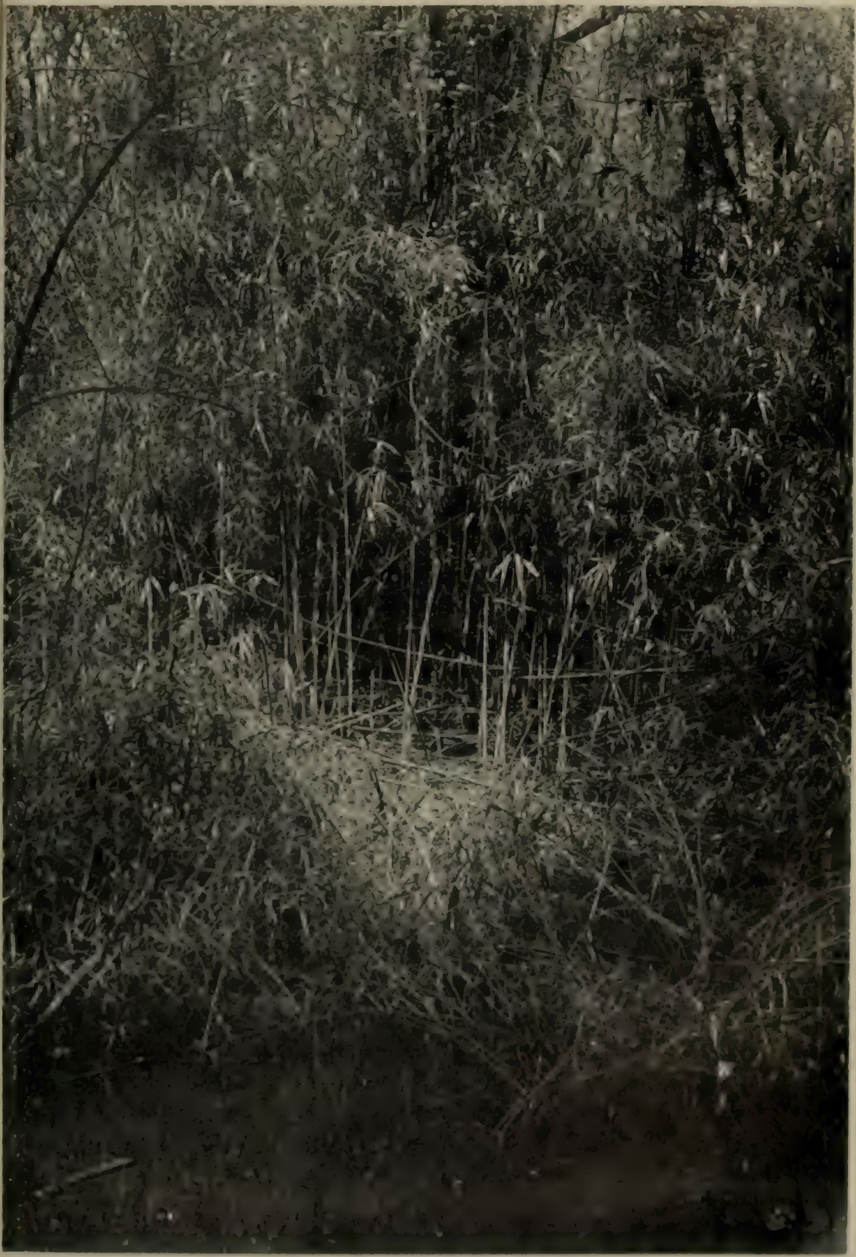

FIGURE 11.—Canebrake habitat in the Ocmulgee River floodplain forest near Macon, Ga. The overstory is mainly ash, hackberry, elm, and ash-leaved maple.

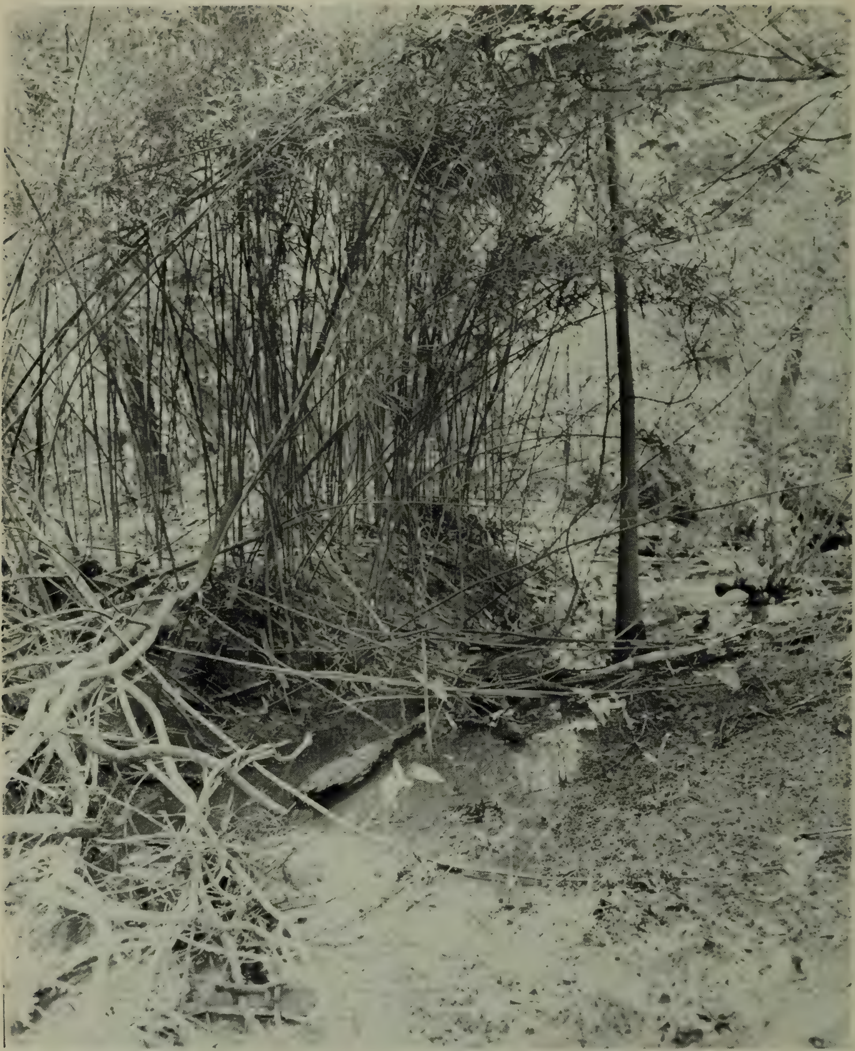

FIGURE 12.—Canebrake habitat in the Ocmulgee River floodplain forest near Macon, Ga. Of 91 territorial males that I observed along the Ocmulgee over a period of years, 87 had territories in canebrakes.

Ocmulgee River floodplain forest in Georgia

In this area the Swainson's Warbler is found in the extensive canebrakes some 3 to 5 miles southeast of Macon in Bibb County in central Georgia (Meanley, 1945). The largest stands I have ever seen of the fast-disappearing canebrake habitat occur in this area. In 1968, there were still some sections in the Ocmulgee

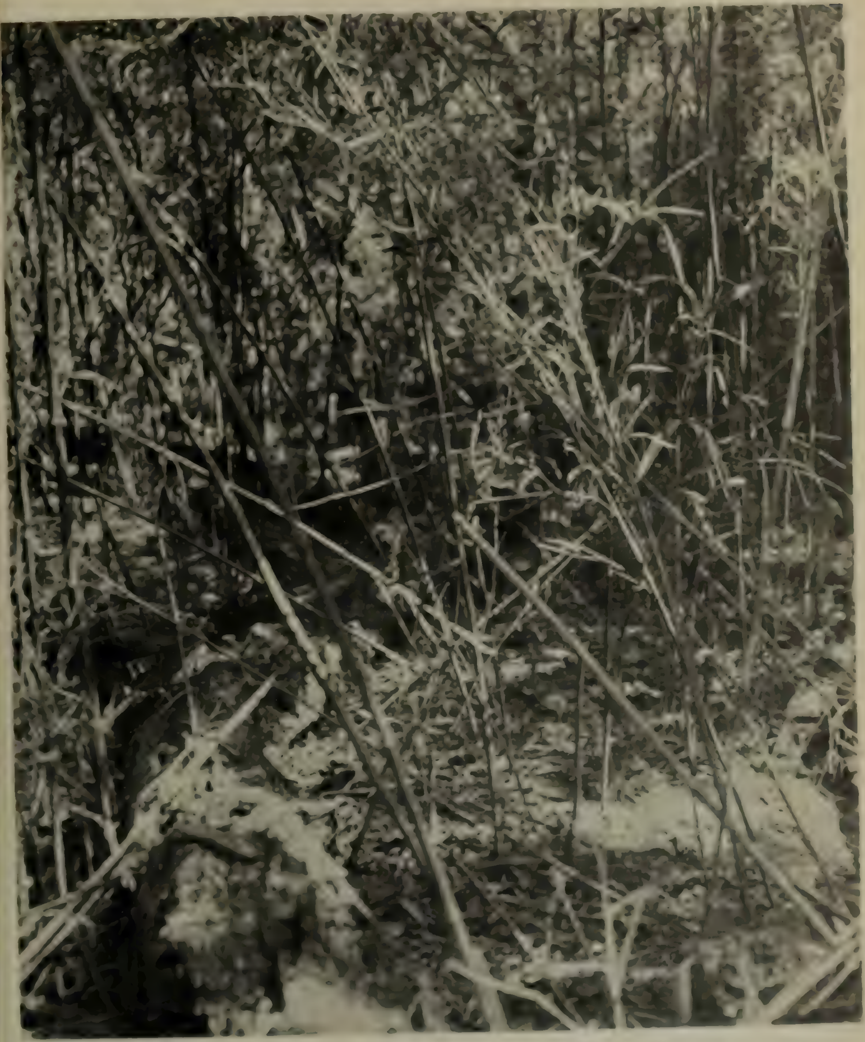

FIGURE 13.—Typical canebrake breeding territory occupied by a male Swainson's Warbler near Macon, Ga., May 1965.

floodplain forest where canebrakes, nearly uninterrupted, covered 1-square-mile areas. The cane poles in these stands averaged about 15 feet in height and three-fourths of an inch in diameter at ground level. The largest poles reached 30 feet in height and an inch and a half in diameter at base. In the *Living Bird*, Fifth Annual, (Meanley 1966, p. 155) I published notes on the density of a tract of cane in a male Swainson's Warbler territory (fig. 13) near Macon:

The number of cane poles in 10 quadrats varied from 18 to 75 per 10-foot-square quadrat. There were about 20,000 cane poles per acre in my sample area which was virtually devoid of other plants, except for a scattering of large trees.

Of 91 territorial males that I observed in seven nesting seasons near Macon, 87 had territories (averaging about 1 acre each) in patches of cane growing beneath the floodplain forest canopy. The floodplain forest in this area was composed mainly of the following trees (in descending order of abundance): hackberry *(Celtis occidentalis),* boxelder *(Acer Negundo),* red ash *(Fraxinus pennsylvanica),* American elm *(Ulmus americana),* sweetgum, water oak, swamp chestnut oak *(Quercus Michauxii),* silver maple *(Acer saccharinum),* and mulberry (*Morus* sp.). The understory was mostly cane, but in openings included blackberry (*Rubus* sp.), swamp privet *(Forestiera acuminata),* or saplings of the above-mentioned trees. The coverage of the combined strata of upper canopy, lower trees, and understory was about 85 percent. Twelve exposure meter readings, made at feeding sites of four Swainson's Warblers, ranged from 100 to 225 footcandles.

The ground in areas occupied by the warblers is dry except during periodic flooding. During three nesting seasons when I entered the floodplain forest the water was 6 feet deep in some canebrake areas where I usually conducted studies. Sometimes these floodwaters recede in less than a week, and the habitat returns to normal. Such flooding sometimes occurs during the height of the nesting season, with a devastating effect on nesting success, since the average nest height is about 4 feet, and some nests are only a foot and a half from the ground.

A 7-acre tract of cane about 3.5 miles southeast of Macon had three territorial males in 1944, five in 1945, four in 1963, and one in 1968. There was gradual reduction in the amount of cane in this tract over the 24-year period. In 1968, I counted 19 territorial males along a 2-mile transect about 5.5 miles southeast of Macon in an area known as Bond Swamp.

The following notes that I made on breeding bird associates appeared in the *Living Bird,* Fifth Annual, (Meanley 1966, p. 158–159):

> In the Ocmulgee River floodplain forest near Macon, the nesting species in closest association with the Swainson's Warbler were the Cardinal *(Richmondena cardinalis),* Hooded Warbler *(Wilsonia citrina),* and the White-eyed Vireo *(Vireo griseus).* All three nested in or on the edge of canebrakes as well as in other plant associations. The Cardinal fed mainly along the edge of cane thickets and in forest openings such as logging roads. The Hooded Warbler, which fed regularly from 2 to 30 feet above the ground,

ranged through the more open growths of cane as well as the more open parts of the forest undergrowth. The White-eyed Vireo preferred mostly a less homogeneous habitat, more often the edge of viney thickets, and usually fed from 5 to 20 feet above the ground.

Other species, present in canebrakes but not so closely associated with the Swainson's Warbler, were the Carolina Wren *(Thryothorus ludovicianus)*, Kentucky Warbler *(Oporornis formosus)*, Rufous-sided Towhee *(Pipilo erythrophthalmus)*, and Prothonotary Warbler *(Protonotaria citrea)*. The Carolina Wren ranged throughout the floodplain forest, especially about old logs and brush piles. The Kentucky Warbler occurred most often where there was a denser ground cover, particularly of herbaceous plants, than in the canebrakes. The Towhee, a ground-feeder like the Swainson's and Kentucky Warblers, fed in the canebrakes but usually where the leaf litter and cover was thicker than in the areas used by the Swainson's Warbler. The Towhee also fed in other parts of the forest and in the edge of habitats. The Prothonotary Warbler preferred the banks of streams that flowed through the canebrakes and the vegetation along the banks.

During migration, Worm-eating Warblers and Ovenbirds *(Seiurus aurocapillus)* moved through the canebrakes as well as other parts of the floodplain forest.

The Great Dismal Swamp

This extensive southern swamp a few miles south of Norfolk, Va., covers an area of about 600,000 acres in Nansemond and Norfolk Counties, Va., and in Pasquotank, Gates, and Camden Counties, N.C. In 1968 the Swamp was still a great wilderness, but with no virgin timber remaining. The part of the Swamp in which the Swainson's Warbler occurs is generally devoid of surface water (but low and damp) owing to drainage in connection with logging operations during the past 200 years. Being on low flat land with a high water table, some Swainson's Warbler territories are partially inundated after heavy rainfall.

The Dismal Swamp is quite diversified floristically but in the past apparently was predominantly forested with swamp blackgum *(Nyssa silvatica* var. *biflora)* (Kearney, 1901). It is in the remnant of this forest type, now of mixed species composition, that the Swainson's Warbler is mainly found today.

I examined such a mixed forest community along the northern end of Jericho Ditch (fig. 14), about 3 miles southeast of Suffolk, Va., in June 1966 and found that it was composed of the following plants: Predominant trees of the upper canopy were swamp blackgum, red maple *(Acer rubrum)*, sweetgum, willow oak *(Quercus phellos)*, water oak, tulip poplar *(Liriodendron Tulipifera)*; lower trees were American holy *(Ilex opaca)*, paw-paw *(Asimina triloba)*, swamp magnolia *(Magnolia virginiana)*, and red bay *(Persea borbonia)*; undergrowth was mainly sweet pepperbush and greenbrier, but netted chain-fern *(Woodwardia areolata)*

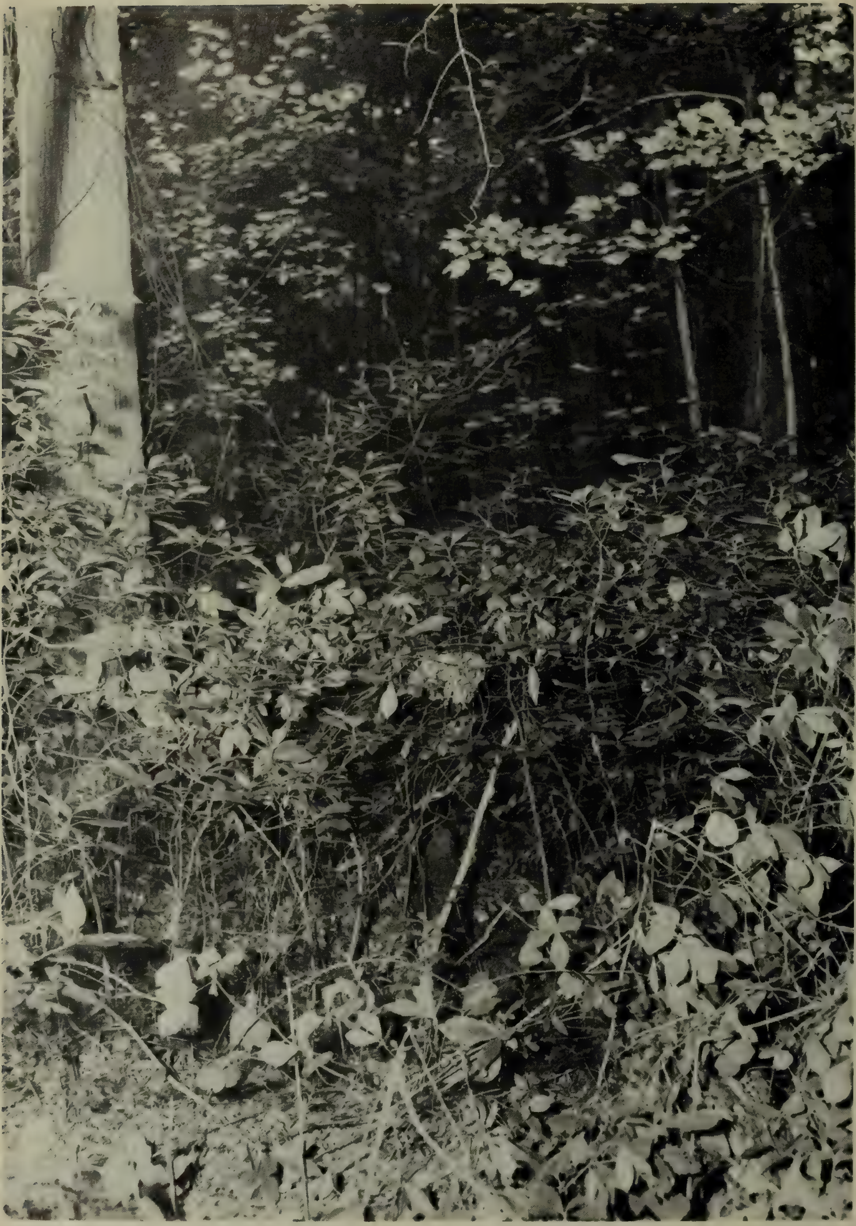

FIGURE 14.—Mixed swamp hardwood habitat in the Dismal Swamp in southeastern Virginia, 1968. Major forest species are swamp blackgum, sweetgum, and red maple. Note Swainson's Warbler nest 2 feet from the ground in sweet pepperbush, center of picture.

overed the ground where there was more light. The Swainson's Warbler foraged mostly in openings between clumps of sweet epperbush and greenbrier and in the small pure stands of weet pepperbush. It nested mostly in the greenbrier tangles. A ommunity of this composition also is the major Swainson's Warbler habitat in the Pocomoke Swamp on the Eastern Shore of Maryland.

I counted eight territorial males along a 0.5-mile transect in the icinity of the Virginia–North Carolina line on April 20, 1958. Bird associates during the breeding season in the sweet pepper-ush–greenbrier undergrowth are the White-eyed Vireo, Prothono-ary Warbler, Prairie Warbler *(Dendroica discolor)*, Ovenbird, Hooded Warbler, and Cardinal. The presence of the Prairie War-ler in this habitat was most unexpected, since nowhere else have encountered it breeding in closed-forest habitat. An interesting reeding bird of this same swamp forest, but at higher elevations, s Wayne's Black-throated Green Warbler *(Dendroica virens aynei)*.

ayou Boeuf Swamp, La., and Monkey John Swamp, S.C.

Observations were made in the scrub palmetto breeding ground abitat in Bayou Boeuf Swamp near Alexandria, La., in the spring f 1956 and 1957, and in Monkey John Swamp near Savannah,

IGURE 15.—Part of scrub palmetto territory of a male Swainson's Warbler in Monkey John Swamp, Jasper County, S.C., May 1964.

Ga., (fig. 15) in the spring of 1964. The physical features of these two areas were quite similar. Red ash, American elm, water oak, sweetgum, and hackberry formed an important part of the forest in both areas.

In Monkey John Swamp the density of the combined layers of the upper canopy and lower trees was about 90 percent. The undergrowth, almost entirely scrub palmetto, averaged about 3 feet in height, with about 800 plants per acre. Most of the ground area beneath the palmettos was dry. Wet spots under the palmettos in the territory of a Swainson's Warbler were generally avoided.

In the scrub palmetto habitat of Bayou Boeuf Swamp, I found a population density of 10 territorial males per 100 acres in April 1957.

Western Kentucky

R. M. Mengel (1965, p. 69) states that the ridge bottoms—

> the driest habitat of the alluvial forests, contain the finest broadleaf forest and the richest small bird populations of the region. It is in such areas that Swainson's Warbler is most numerous.

These are the cane ridges so favored by the Swainson's Warbler in the lower Mississippi Valley.

SOUTHERN APPALACHIANS

In the Southern Appalachians the Swainson's Warbler is primarily associated with the moist lower slopes of mountain ravines and various drainage systems of the Mixed Mesophytic Forest Region. On these lower slopes, where the proportion of hemlock in the mesic forest increases, rhododendron is often the main understory species; and it is within this association (figs. 16–17) that the warbler is most often found. It also occurs in some cove hardwood forests (fig. 18), where the understory may be composed of a heterogeneous growth of deciduous shrubs, and in other habitats.

In areas where the Swainson's Warbler is locally common, individuals of a population may "spill over" from optimum to marginal habitats, as cited by Brooks and Legg (1942, p. 70–80), who in West Virginia found a singing bird near the top of a ridge in a thicket beneath dead chestnut *(Castanea dentata)* trees. Parnell and Quay (1964, p. 139) reported a few Swainson's Warblers in dry sites, such as an oak-hickory forest in Toxaway Gorge in western North Carolina.

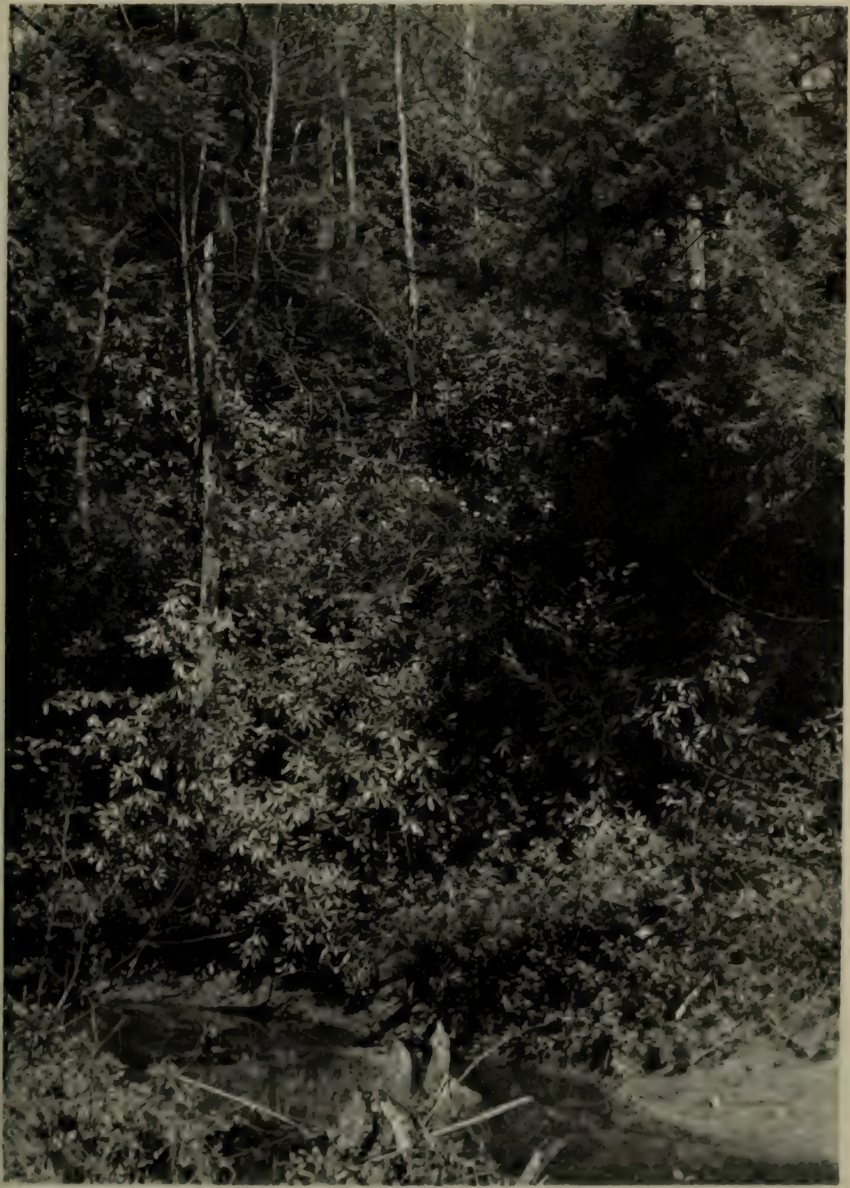

FIGURE 16.—Rhododendron-hemlock association. Mountain breeding habitat of the Swainson's Warbler along Collison Creek, on the Allegheny Plateau, Nicholas County, W. Va., May 15, 1966.

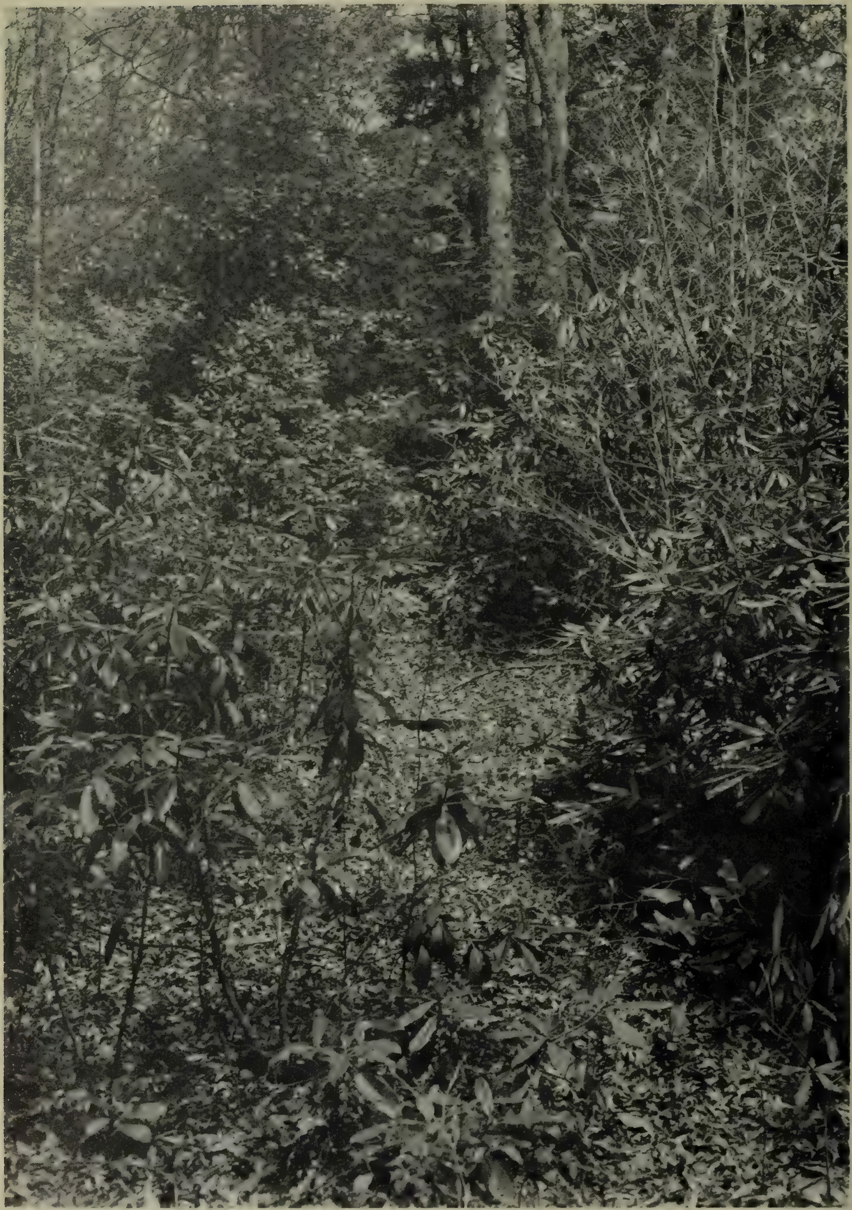

FIGURE 17.—Mountain breeding habitat, Collison Creek, Nicholas County, W. Va.

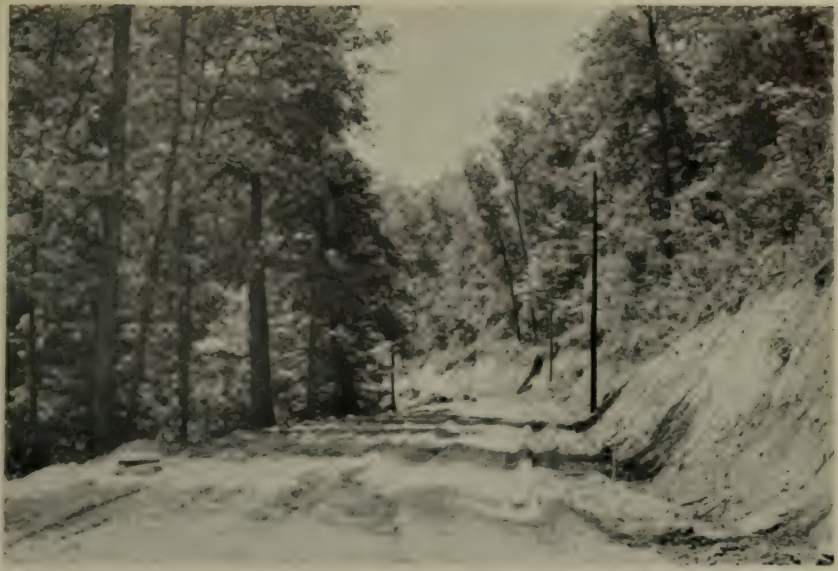

FIGURE 18.—Mature mountain cove hardwood habitat of the Swainson's Warbler near Charleston, Kanawha County, W. Va., May 1965. Tulip poplar is the dominant plant species.

Allegheny Plateau in West Virginia

In West Virginia the Swainson's Warbler is best known from the rugged Allegheny Plateau region of the south-central and southwestern part of the State. Studies of its habitats have been concentrated mainly in the Mt. Lookout section of Nicholas County along the Gauley River drainage (Brooks and Legg, 1942), and at Charleston in the Kanawha River area (Sims and DeGarmo, 1948).

In the Mt. Lookout region Brooks and Legg (1942, p. 78–79) found Swainson's Warblers in virtually all areas containing tangles of rhododendron, mountain laurel *(Kalmia latifolia)*, hemlock, and American holly. In May 1940 they recorded 10 or 11 singing males within 1.5 miles along Franzy Creek, a small branch of Collison Creek.

On the south side of the Kanawha River, in Donley Hollow, at the edge of the city of Charleston, Eleanor Sims found 18 Swainson's Warbler nests during 1945–47 (Sims and DeGarmo, 1948, p. 1). This is a rather good indication of the local abundance of the species in this section of the Allegheny Plateau.

At the foot of the mountain where Donley Hollow meets the floodplain the elevation is only 600 feet. As one travels up the

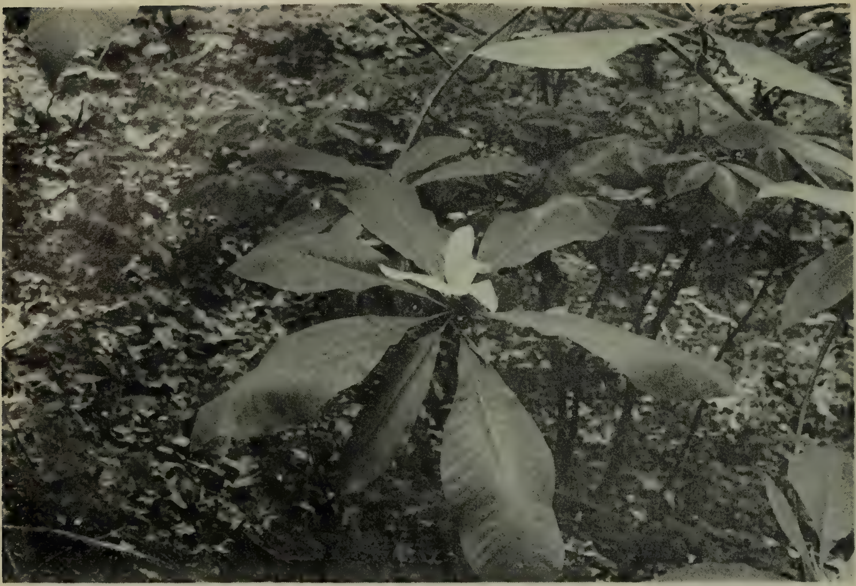

FIGURE 19.—Umbrella magnolia, prominent understory tree in habitat of the Swainson's Warbler near Charleston, W. Va.

ravine beside Donley Branch and climbs several hundred feet higher, Swainson's Warblers can be heard singing on both forested slopes, often two or three hundred feet up from Donley Branch. I counted seven singing males as I walked a mile up the hollow on May 15, 1965. There are probably fewer birds in the hollow now than at the time Sims and DeGarmo made their study, since the lower, moister slopes are now occupied by suburban residences.

The Donley Hollow habitat is like a Costal Plain floodplain forest on the side of a hill. In these moist hollows or mountain ravines the dominant canopy species of the mature cove hardwoods forest is tulip poplar. The diameters at breast height of the four largest tulip poplars in one Swainson's Warbler breeding territory in 1965 were 25, 30, 33, and 36 inches. Other trees of the upper canopy layer were mainly beech *(Fagus grandifolia)*, buckeye (*Aesculus* sp.), black oak *(Quercus velutina)*, red maple, and sweetgum. Lower trees were umbrella magnolia *(Magnolia tripetala)* (fig. 19), dogwood *(Cornus florida)*, and paw-paw. The undergrowth was mainly spicebush *(Lindera benzoin)*, with occasional thickets of greenbrier and Japanese honeysuckle *(Lonicera japonica)*. Thinly distributed herbaceous plants of the ground flora were nettle *(Laportea canadensis)*, mayapple *(Podophyllum peltatum)*, violet (*Viola* sp.), baneberry (*Actaea* sp.), and Christmas fern *(Polystichum acrostichoides)*. Twenty exposure meter readings at Swainson's Warbler feeding sites ranged from 50 to 245 footcandles.

The closest avian associates of the Swainson's Warbler in this habitat are the same as in most Coastal Plain breeding localities: the White-eyed Vireo, the Hooded and Kentucky Warblers, the Cardinal, and the Rufous-sided Towhee.

Toxaway River Gorge

Parnell and Quay (1964) found the Swainson's Warbler to be a common summer resident in Toxaway River Gorge, Transylvania County, N.C., in the summer of 1961. This section of southwestern North Carolina is in the part of the Southern Appalachians where North Carolina, South Carolina, and Georgia come together. There are breeding records from the mountains of all three States.

In Toxaway Gorge, Swainson's Warblers were found at altitudes of 1,200 to 2,800 feet. According to Parnell and Quay (1964, p. 144), these birds—

> showed a preference for dense stands of rhododendron, mountain laurel, and dog hobble *(Leucothoe editorum)* along the narrow riverbottom Pine Flats. The Mixed Mesophytic Coves and Slopes and the Oak Forest were utilized to a lesser degree.

The Pine Flats are generally more mesic, more mature, and less disturbed than the other habitats. Canopy species are white pine *(Pinus strobus)*, Virginia pine *(Pinus virginiana)*, hemlock, and tulip poplar. The understory is mainly rhododendron. The Mixed Mesophytic Cove and Slope Forest canopies included such species as red maple, sweet birch *(Betula lenta)*, hemlock, beech, basswood *(Tilia americana)*, and tulip poplar. They have poorly developed shrub layers, but local thickets of rhododendron and laurel occur. The sparsity of Swainson's Warblers in this forest type may be due to the poorly developed shrub stratum. The Oak Forest gradually becomes differentiated from the Mixed Mesophytic type as the sites become drier. Mountain laurel is the main Oak Forest understory species.

Most of the same avian associates of the Swainson's Warbler as in the Coastal Plain and other localities of the Southern Appalachians are found in Toxaway Gorge. Parnell and Quay (1964, p. 145) list the Worm-eating Warbler *(Helmitheros vermivorus)* as an associate of the Swainson's Warbler. The Worm-eating Warbler is also a nesting associate in the Pocomoke Swamp in Maryland, in the Arkansas River bottoms near Gillett, Ark., and at Charleston, W. Va., Mountain warblers breeding in the Toxaway Gorge included the Black-throated Blue *(Dendroica caerulescens)*, the Black-throated Green *(Dendroica virens)*, the Chestnut-sided *(Dendroica pensylvanica)*, the Canada *(Wilsonia canadensis)*, and the Blackburnian *(Dendroica fusca)*.

Description

SIZE

The Swainson's Warbler is a rather short and stocky bird. Its length, 5 to 5½ inches, is about average for warblers, but it is heavier than most of the Dendroicas and Vermivoras. Four males collected during the breeding season weighed 13.2, 15.4, 16.2, and 16.6 grams (Mengel, 1965; Norris and Johnston, 1958; and L. C. Binford, Louisiana State University Collection). Two females taken in winter, one in Quintana Roo, Mexico, and one in British Honduras, weighed 13.7 and 13.9 grams (L. C. Binford and S. M. Russell, Louisiana State University Collection). A live male at Andros Island, Bahamas, in March, weighed 15.6 grams (Walkinshaw and Walkinshaw, 1961).

A series of birds that struck a Tallahassee, Fla., TV tower in spring migration averaged lighter than those striking the tower in the fall. The mean weight of the spring series of 15 birds was 14.9 grams, whereas the mean weight of the fall series of 19 was 18.9 grams (table 1). The Tallahassee TV tower is less than 50 miles from the Gulf Coast, and birds coming in from a trans-Gulf or circum-Gulf migration would have used up much of their reserve fat; whereas those leaving the United States would have a large fat reserve for the long journey to the wintering ground. Norris (1963, p. 47) reported that two birds that struck a TV tower in the Savannah River Valley in South Carolina on September 24, 1957, were excessively fat: one was recorded as having 19 percent fat, and the other, 24 percent.

TABLE 1.—*Weights of Swainson's Warblers killed at TV tower, Tallahassee, Fla., during migration*

[In grams]

	Spring (15 specimens)	Fall (19 specimens)
Minimum	11.3	14.3
Maximum	15.7	20.4
Mean	14.9	18.9
Median	13.9	18.3
Standard deviation	±1.2	±1.7

Measurements in millimeters of 11 male specimens collected during the breeding season on the Coastal Plain are as follows: Wing,[3] 67.5–72.5 (70.2); tail, 46.5–52.0 (49.1); exposed culmen, 15.0–16.5 (15.3); tarsus, 17.0–19.0 (17.8); middle toe, 12.5–14.0 (13.2). Measurements in millimeters of 10 female specimens collected during the breeding season on the Coastal Plains, are: Wing, 66.0–72.0 (69.0); tail, 46.5–52.0 (49.4); exposed culmen, 14.8–16.0 (15.3); tarsus, 17.5–19.0 (18.2); middle toe, 13.0–14.0 (13.3).

DISTINGUISHING CHARACTERS

Sexes of the Swainson's Warbler are alike. Upperparts, including wings, are brown, except the crown which is reddish brown; underparts are yellowish-white and unstreaked. There is no white in wings or tail. The bill is large, thick at the base, and sharply pointed.

Similar species.—The Worm-eating Warbler has black stripes on its crown. The Ovenbird is streaked below. Immature Connecticut Warblers *(Oporornis agilis)* and Mourning Warblers *(Oporornis philadelphia)* in fall plumage have eye rings.

ADULT PLUMAGE

The crown of the Swainson's Warbler varies from almost cinnamon to chocolate brown, with a barely distinct buffy median stripe from the base of the culmen through the forehead. There is a white or pale yellowish supercilliary (eye) stripe, a dusky spot in front of the eye, and a brownish postocular streak. The sides of the head are otherwise pale buffy brownish. Back, scapulars, rump, upper tail coverts, tail, and wing coverts are olive brown or olive-grayish brown. Tertials are warmer brown (toward mummy or prouts brown); secondaries and primaries are dusky, edged with brown. (The closed wing appears browner than the back). Underparts are yellowish white to nearly plain white (possibly geographic variation), shaded with olive or olive-grayish on the sides. Adults in autumn are indistinguishable from breeding birds.

The bill is brownish, except the undersurface of the lower mandible, which is flesh colored. The iris is brown. Legs and feet are of a pale (pinkish) flesh color. The culmen is slightly curved, narrowed, and elevated between the nostrils. The foregoing description of plumage and soft parts is partly from R. Ridgway (1902 p. 436–437).

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[3] Wing measurements are for the chord, from bend of wing to tip of longest primary.

JUVENILE PLUMAGE

The juvenile wings and tail are similar to those of adults. Upperparts are brown; throat and chest are dark brown; and other underparts are mottled brown and white. There is no whitish line over the eye.

GEOGRAPHIC VARIATION

Breeding birds from the Southern Appalachians differ from Coastal Plain birds in that underparts tend to be whiter (less tinged with yellow). The underparts of 15 Coastal Plain specimens in breeding plumage were primrose yellow; whereas seven mountain specimens in breeding plumage were almost immaculate below but had a light suffusion of napthalene yellow on breast and abdomen. There is no significant size difference between these two forms.

The mountain form was described as a new subspecies by B. Meanley and G. M. Bond (1950, p. 191–193) and is known as *Limnothlypis swainsonii alta* (Appalachian Swainson's Warbler). The type specimen, adult male, United States National Museum No. 362424, was collected at Walhalla, S.C., on June 25, 1940, by W. M. Perrygo and S. Y. Hoyt (original number 4,681).

MOLTING

Virtually nothing is known of the molt of this species. M. G. Vaiden (1940, p. 126) collected a male in partial molt on July 17, 1939, in Sunflower County, Miss.

Breeding Biology

TERRITORIAL BEHAVIOR

Arrival on the breeding grounds

The Swainson's Warbler is one of the last of the southern warblers to arrive on the breeding grounds, but it is earlier than most of the northern transient members of the family. When I visited the Dismal Swamp on April 11, 1969, all of the resident breeding warblers except the Swainson's Warbler had returned. Wayne's Black-throated Green Warbler had already begun to nest. Since the foliage was only about one-third out, and since Swainson's Warbler occupies the shadiest part of the swamp, its late appearance is probably timed with that of the foliage.

Since males sing the first day on the breeding grounds, the schedule of their arrival is better known than that of females; but females have struck the TV tower at Tall Timbers Research Station, Tallahassee, Fla., as early as the first week in April (William Dopson and James B. Cope, personal communication). At the Dismal Swamp in southeastern Virginia, earliest males have been recorded as arriving on April 15. On April 20, 1969, I observed a mated pair on their breeding territory in this swamp.

In the relatively late season of 1966, at my Macon, Ga., study area, the local male population arrived during a period of about 1 week. The first four males arrived on April 12; by the next morning there were eight males; there were nine on the 14th, and ten on the 15th, the date I departed from the area. When I returned on April 28 there were 19 males in the area. Apparently the males, and probably the females, arrive at night. I was on the breeding grounds 2 whole days preceding the arrival of the first males on the 12th, and on that morning I was there before dawn. At daybreak on April 12, I heard the first Swainson's Warbler.

Homing

Individuals that establish a territory one year may return to the same place in succeeding years. John Weske banded a Swainson's Warbler on territory in the Pocomoke Swamp in Maryland in May 1960, and the bird was recovered at virtually the same place the following four seasons by mist-netters David Bridge and Vernon Kleen. In my study area in the Dismal Swamp, a marked male occupied the same general territory for 3 successive years.

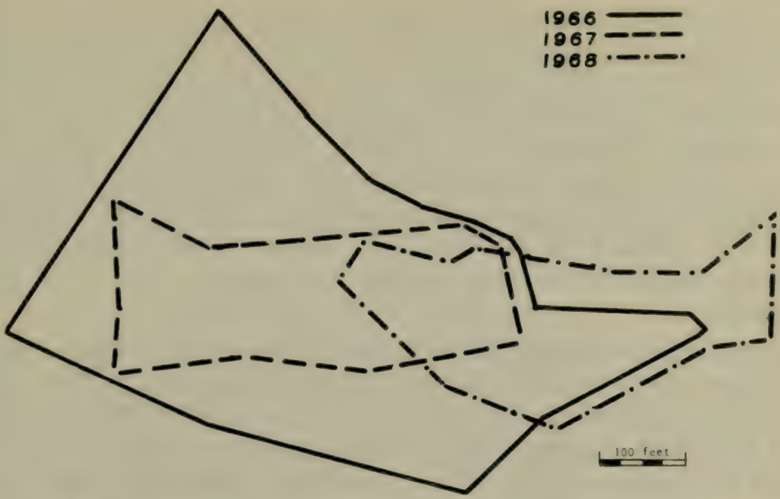


FIGURE 20.—Overlapping territories occupied by the same (marked) male Swainson's Warbler for three successive years (1966, 1967, 1968) in the Dismal Swamp in Virginia.

Territories

Males establish territories soon after arrival on their breeding grounds. The size and distribution of territories in an optimum area may depend upon the extent and arrangement of the habitat, as well as upon competition with other male Swainson's Warblers for food and space. Where prime habitat is limited in extent, it may support several territories, thus creating a group or "colony" of birds. This situation frequently occurs in southern canebrakes and is not unlike breeding "colonies" of the Kirtland's Warbler *(Dendroica kirtlandii)* in Michigan jack pine *(Pinus Banksiana)* habitat. In a 7-acre canebrake in the Ocmulgee River floodplain forest near Macon, Ga., there were four territories, and not all of the canebrake was occupied.

Sprunt and Denton (in Griscom and Sprunt, 1957 p. 51) reported that four territories in Georgia ranged in size from 0.72 to 0.91 acre (table 2). Two of the territories were adjacent and two were not. The smallest territory that I measured at Macon contained only 0.3 acre (table 2). It was in a block of woodland approximately 2 acres in size and was separated from the main forest by a cleared powerline right-of-way 50 yards wide.

In the Dismal Swamp, prime habitat is spotty; the territories are farther apart and larger than in the Ocmulgee River floodplain forest, where optimum habitat often occurs in larger blocks. The territory of one paired male in the Dismal Swamp covered nearly 6 acres, and that of another nearly 4 acres (table 2). The overlapping territories occupied by the same Dismal Swamp male in 1966, 1967, and 1968 (fig. 20) contained 4.8, 1.7, and 1.6 acres respectively. In contrast, territories in the floodplain forest canebrakes seldom exceeded 1 acre. In two Dismal Swamp territories, only a part of each defended area was suitable for feeding and nesting; whereas in the canebrakes virtually all of the defended area was utilized for feeding. The "excess" area of the Dismal Swamp territories is used mainly for singing, but it is also defended.

Sometimes in discontinuous habitat a male may occupy a split territory or a territory composed of separate segments. One such territory in Monkey John Swamp, a few miles north of Savannah, Ga., had three segments. Two of the segments were on opposite sides of a cypress *(Taxodium distichum)* pond; the third was across a road from the pond. The occupied segments totaled 0.6 acre (table 2).

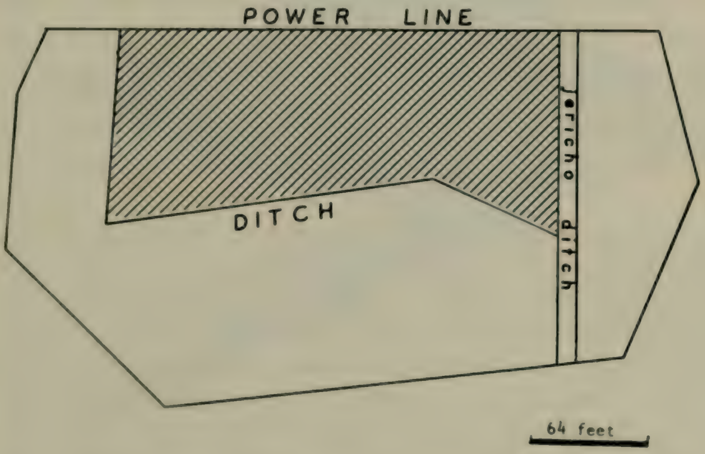
TABLE 2.—*Size of Swainson's Warbler territories*

Locality	Size (acres)	Reference
Ocmulgee River bottom, Bibb County, Ga.	0.3	Meanley, 1969, p. 247.
Monkey John Swamp, Jasper County, S.C.	0.6	Do.
Savannah River bottom, Richmond County, Ga.	0.72	Griscom and Sprunt, 1957, p. 51.
Do.	0.79	Do.
Ocmulgee River bottom, Bibb County, Ga.	0.83	Do.
Little River Swamp, Tift County, Ga.	0.91	Do.
Dismal Swamp, Nansemond County, Va.	1.7	Meanley, 1969, p. 247.
Do.	3.9	Do.
Do.	4.8	Do.

Males may remain in the same area for most of the summer. One marked Arkansas male occupied the same territory for at least 4 months (April 15 to August 15). Six males occupied the same territories in my Dismal Swamp study area from April 20 to at least June 30, the date of my last visit that season.

However, shifting of boundaries takes place from time to time, and the size and shape of territories change. In the Dismal Swamp where Swainson's Warblers have plenty of room to spread out because of low population densities, and where territories are seldom contiguous, a territory may retain its identity throughout the breeding cycle.

During various phases of the breeding cycle different parts of the territory may receive major use, but the original territory ablished by the male shortly after arrival on the breeding unds may be defended at any time. When the male is not paired uses most of the territory. If the first nest is destroyed, and male and female become separated before the start of a ond nesting attempt, the whole territory may be used. The part ed is smallest during the mating and nest-building periods g. 21), and sometimes during egg-laying. Stenger and Falls 1959, p. 136) found that the area utilized by Ovenbirds was arger during the premating, mating, incubation, and nesting eriods than during nest-building and egg-laying.



IGURE 21.—Variation in size of the territory of a male Swainson's Warbler during breeding season. Only the hatched area (with densest cover) was occupied during the courtship and mating period. Dismal Swamp in Virginia, April 1969.

Swainson's Warblers usually occupy larger territorial areas uring the first few days after their arrival on the breeding rounds; and after the nesting season males that remain on their erritories may extend the boundaries considerably. A male in the ismal Swamp that occupied 4.1 acres in May and June occasionlly extended his range over an 8-acre area in July.

The size and shape of a territory changes during each nesting ttempt, because a different nest site is chosen each time and the ites may be several hundred feet apart. The male gives the nest ite a wide berth when the female is incubating, thus giving the ppearance that the nest is out of the territory when actually it is nside near the edge. The part of the territory most frequented by ne Dismal Swamp male during a first nesting attempt was avoided during the second nesting when the female built her nest there and started incubating.

Defense of territories

Territories are defended by singing, chasing, and combat. The song signals ownership, and each male's primary advertising song is usually different from his neighbor's.

Paired males appear to be more aggressive than unpaired males and usually initiate border encounters, which most often take place along territory boundaries. A paired and an unpaired male with adjacent territories at Macon, Ga., contended each time at virtually the same point along the boundary. As these males chased each other along the boundary, the paired female was close by but remained 10 to 15 feet within her territory, chipping excitedly.

A territorial male with an incubating mate at Pendleton Ferry, Ark., apparently had more time for hostile activity and thus was involved more often than the Macon paired male, which I observed during preincubation traveling with his mate. The Pendleton Ferry male would fly from any point in his territory deliberately to start a fight at the mutual boundary. He always began chipping excitedly as he moved toward his neighbor's territory, and both males chipped constantly during border clashes. In addition to chasing, the birds fluttered about on the ground after making contact and sometimes flew together a few feet up from the ground, grasping each other's bill.

Sometimes when a male invades a neighbor's territory and is chased out, he may perform a display on his side of the boundary. Such displays most often occur immediately after prolonged encounters. The wing and tail feathers are spread laterally (fig. 22), and the tail is vibrated. The bird sidesteps back and forth along a branch, frequently turning around, all the time chipping excitedly. Ficken and Ficken (1962, p. 110) observed a similar display in the Redstart *(Setophaga ruticilla)*. At the end of a chase in which its adversary is evicted from the territory, a Swainson's Warbler male may fly up to a perch and sing vigorously for 10 to 15 seconds.

Following boundary encounters, males drift back into their territories and usually sing unbroken courses of songs for several minutes. Sometimes they start singing close to the boundary, in which case songs are incomplete, consisting only of the first two or three notes. Then as they move farther into their respective territories, they sing more complete songs.

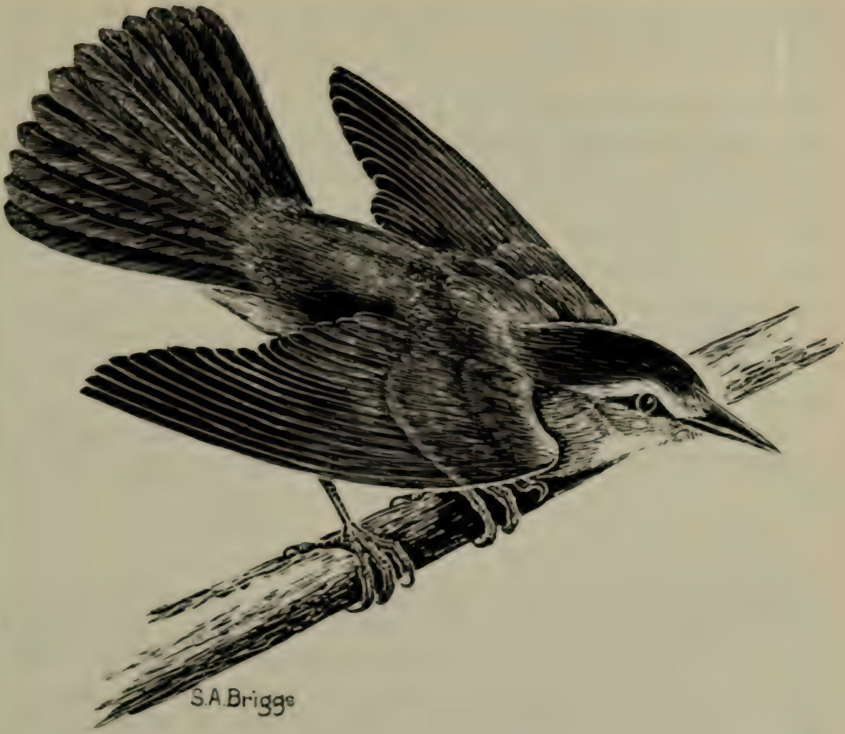


FIGURE 22.—Display of a male Swainson's Warbler during or immediately following a boundary dispute with a neighboring male. The display resembles a female soliciting copulation. The wings are quivered, the tail feathers are alternately spread and closed, and the bird may step sideways back and forth along the limb.

There is usually little antagonism toward other species, and vice versa. White-eyed Vireos, Prothonotary Warblers, Hooded Warblers, Cardinals, and occasionally other species nest in territories of the Swainson's Warbler and, like the Swainson's Warbler, live close to the ground. On one occasion I saw a Hooded Warbler chase a Swainson's Warbler, after which the latter flew to a high branch within its territory and sang vigorously for about 10 seconds.

COURTSHIP AND MATING

I have never been present the minute the pair-bond was formed, nor have I witnessed male courtship displays before pair formation.

On one occasion when a female entered a male's territory for what I believe was the first time, she was chased for short distances but not driven beyond the territory boundary. The action of the two birds reminded me somewhat of the well-known sexual chase of Red-winged Blackbirds *(Agelaius phoeniceus)*, when the females arrive on the breeding grounds.

During prenesting I observed a display by a paired male where he assumed a posture similar to a female ready for copulation. The posturing occurred when the male was perched about 3 feet from the ground and was approached by the female to within about 1 foot. When the female alighted near the male, he uttered a faint *twee-twee-twee* that was barely audible from where I was standing less than 8 feet away. The next day under similar circumstances, the same male extended his rump feathers only and uttered the same faint notes.

Also during prenesting, a paired male was observed to perform a "moth" or floating" flight. I could not locate the female at the time.

Vocalizations

During the courtship and mating period, a pair spends most of the day foraging on the ground, usually within 30 feet of each other and often only 2 to 3 feet apart. The male sings very little during this period and is otherwise less vociferous than the female. He may do some sustained singing early in the morning, usually before 7 a.m. I spent 3 consecutive days in the territory of one male, and after 7 a.m. on these days he sang four, none, and two primary advertising songs. During the day singing was more subdued and appeared to be for the purpose of singnaling the female when she was momentarily out of contact with the male. Sometimes a song was incomplete, consisting only of the first, second, or third notes.

Vocalizations other than song are used by the pair to maintain contact. "Chipping" by the female is the most obvious and frequently used vocalization. Some females chip often enough for the investigator to follow a pair during most of the day in habitats where he can move about easily.

The chipping of the female often differs from the conventional alarm (chip) notes of both sexes. At times the chip note is more subdued, more of a squeak, and toward the end of the vocal performance the notes run together into a sort of muted chatter. At that point the chipping has the ring of excitement, and has attracted the male, who may attempt copulation.

Sometimes a very faint *chip* (that I could barely hear at 20 feet) is used by both members of the pair. This is a single chip, well-spaced and not in a series like constant chipping when the birds seem excited. A paired female sometimes utters a faint *zeep* when a male in an adjacent territory sings.

On one occasion a pair that I had under observation was joined by a third bird, presumably a female. The visiting female fed with the pair for about 4 minutes, and at no time was chased by the male. The paired female chipped constantly while the interloper remained.

Pouncing

During the mating period males resort to pouncing on the females. The male flies to the female, who usually is foraging on the ground, and either pecks her rump feathers or pounces on her. I observed this behavior for several breeding seasons before I was sure that sometimes copulation was taking place. It was difficult to believe that copulation could occur under such circumstances. Hann (1937, p. 154) also had difficulty in observing copulation during similar behavior by Ovenbirds on the ground:

> When copulation takes place on the ground, it is practically always accompanied by a struggle, which looks more like mortal combat than sexual intercourse. The fact that the female does not flee, and may even court the procedure, however, dispels any doubt as to her willingness. When they emerge from the struggle, the male usually flies to a nearby perch with an evident feeling of satisfaction, and the female, after shaking her ruffled feathers, proceeds with her eating or nest building.

Essentially the same behavior is exhibited by the Swainson's Warbler.

Pouncing may occur with or without an "invitation" from the female. Most of the time the female appears to be unaware that it is going to happen. Sometimes the female's excited chipping immediately preceeds the stalking and pouncing.

After observing pouncing behavior a few times, I could always anticipate when it was going to happen. The male, feeding on the ground, usually within 20 feet of his mate, discontinued feeding and mounted a branch or log, usually 6 to 12 inches from the ground. Then he remained virtually motionless in a crouched position for 1 to 5 minutes, facing and watching the female who was foraging on the ground or perhaps preening. In his crouched position the flank feathers of the male were slightly fluffed out, and his head was drawn in close to his body. Occasionally he would slowly move his head slightly to one side. When the female moved too far out of range, the male shifted to a closer perch and continued his crouched stance. His performance reminded me of a cat getting ready to pounce on its prey. He would then fly to the female, and the two would flutter together on the ground. Sometimes the male stopped short of the female, and sometimes when contact was made copulation did not take place. The female sometimes responded with a faint *tweet-tweet-tweet.* Following such an encounter, the male might fly off singing a song as loud as the primary advertising song but not resembling it. These flights were sometimes upward in a sort of spiral. One male I watched often sang a whisper song after pouncing. Usually, however, the pair started feeding within a few feet of each other and near the spot where pouncing occurred. Pouncing is also known in the Red Warbler *(Ergaticus ruber)* (Elliott 1969, p. 188).

Nice (1943, p. 174–175) reported Song Sparrow *(Melospiza melodia)* pouncing as a form of courtship display "confined typically to the early stages of the nesting cycle." The male flies down to his mate, collides with her, and then flies away singing. Nice states that pouncing by the Song Sparrow early in the season has no immediate connection with copulation.

> Pouncing on the mate occurs during the long period while song is inhibited and also during building. It may be a technique of the male for impressing himself upon his mate during the time of silence, of making his presence keenly felt.

Howard (1929, p. 22) observed that after the sexual chase recently paired Yellow Buntings *(Emberiza citrinella citrinella)* flutter together on or near the ground or peck each other as they rise in perpendicular flight, like fighting males. Howard believed that the sexual chase and pouncing show that the male is ready to copulate and that the female is not ready to receive him.

One male that I watched for 2 days pounced about three times each hour; another that I watched for 3 days before the beginning of nest building pounced about once every 10 minutes. A third male pounced about once an hour on the day nest building began; nest building was sporadic that day and occurred mostly in the morning, for just 2 or 3 minutes following pouncing.

Copulation occasionally occurs while the female is perched on a limb of a shrub or tree. When copulating in this manner the male sometimes holds onto the female's crown feathers.

NESTING BEHAVIOR

Nesting period

The prenesting period for paired Swainson's Warblers is relatively brief, for nesting begins soon after pair formation. For example, I visited the breeding grounds in the Dismal Swamp on April 12, 1969, at which time the Swainson's Warblers had not yet returned. When I returned on April 20, I found birds paired in at least one territory, and by April 23, nest-building had started in that territory.

The earliest nesting anywhere is reported by Wayne (1910, p. 150) who collected eggs containing small embryos on April 28, at Charleston, S.C. However, May 1 is about the average date for the beginning of nesting throughout the Swainson's Warbler range.

Nest building at Macon, Ga., and Pendleton Ferry, Ark., started about 3 weeks after the first males arrived on the breeding grounds. A completed nest ready for eggs was found at Macon on April 27, 1946, and nests with full clutches were found by May 3, 1945. A nest containing one Swainson's Warbler egg and three Brown-headed Cowbird *(Molothrus ater)* eggs was found at Pendleton Ferry on May 1, 1967. This nest was probably constructed during the third week in April.

In the Dismal Swamp the earliest record of nest building is April 23, 1969. This is about 8 days after the average arrival date of first males. In this same area I observed two nests under construction on May 1.

On the Allegheny Plateau near Charleston, W. Va., Sims and DeGarmo (1948, p. 4) state, nest building begins about 2 weeks after arrival on the breeding grounds. They found a completed nest as early as May 1.

Renestings or second nestings occur throughout June and into early July. Perhaps the latest date is a nest with slightly incubated eggs found on July 13, 1886, at Savannah, Ga. (Perry 1886, p. 188). Young from this nest would have fledged about August 1.

Nest site and materials

For three or four days before nest building, and possibly longer, another activity of the pair is the examining of nest sites. The male of a pair that I watched at this activity led the way more than his mate, and at times he examined nest sites alone. One might therefore conclude that the male selects the nest site.

The average height of 10 nests in various localities was 4 feet 0 inches, with a range of 1 foot 9 inches to 6 feet 3 inches. Nests are usually built in the predominant understory vegetation (fig. 23). In the Dismal Swamp, nests are frequently placed in greenbrier vines (fig. 24), as well as in Japanese honeysuckle, sweet pepperbush, and switch cane *(Arundinaria tecta)*.

Most nests in my Dismal Swamp study area were located within 30 feet of a road or path. Vegetation in these situations is denser because of better exposure to light.

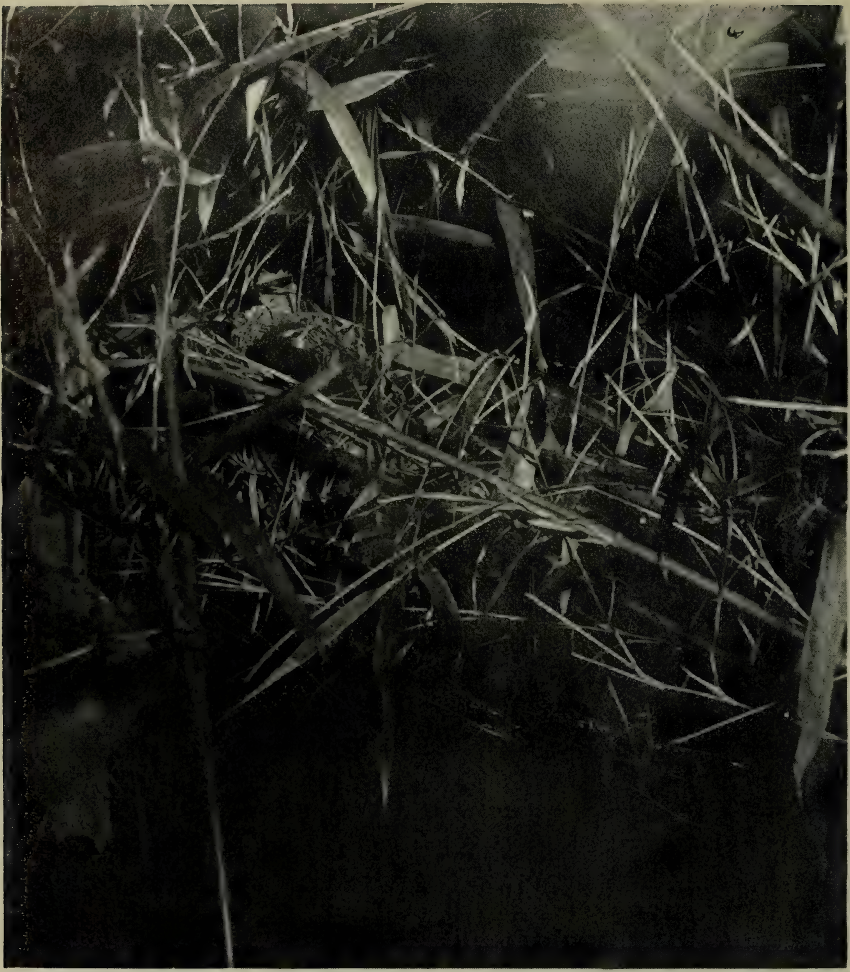


FIGURE 23.—A Swainson's Warbler incubating during flood stage in Ocmulgee River floodplain forest near Macon, Ga., May 1946. Water is 3 feet deep.

In Bayou Boeuf Swamp in central Louisiana, one nest in a scrub palmetto thicket was placed in a blackberry vine in such a way that it was directly beneath the broad frond of a scrub palmetto. The nest was completely shielded from above as if it had a roof over it 4 inches from the rim.

In a canebrake the nest is rarely located in the densest part of the stand, but is usually nearer the edge where the stand is thinner and the cane poles are smaller. In a mature mountain cove

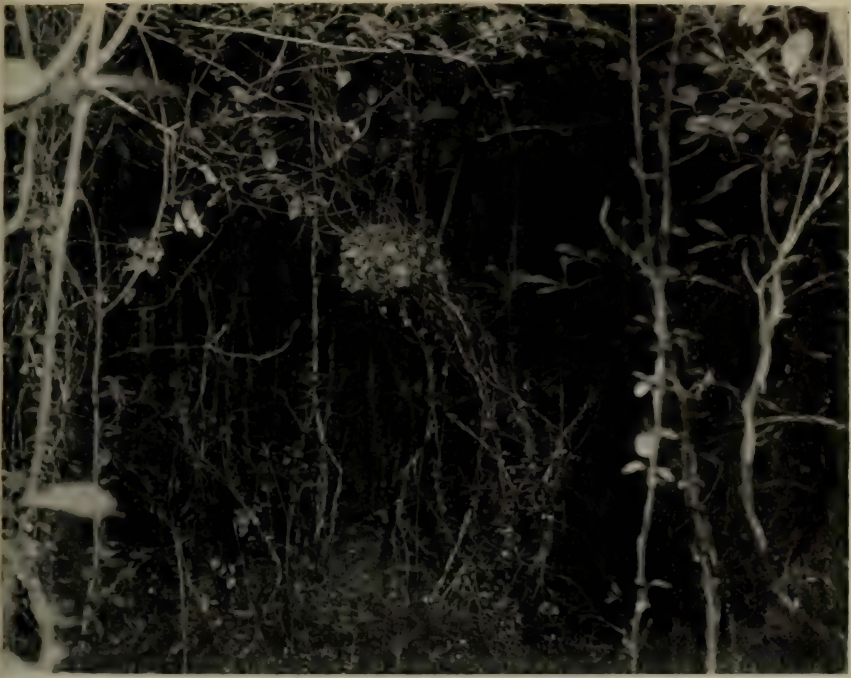


FIGURE 24.—Swainson's Warbler nest in greenbrier vine, 2 feet above the ground, Dismal Swamp in Virginia.

hardwood forest at Charleston, W. Va., Sims and DeGarmo (1948, p. 4) found that—

> the bird avoids placing the nest in dense cover, yet in all instances, a patch of some type of such cover is within a distance of twenty-five to fifty feet. In many cases, this thicket is a growth of greenbriar but may be grape, honeysuckle, blackberry or bittersweet. There appears to be a definite effort to locate the nest in such a manner that it is in close proximity to a screen of protective cover.

All nests that I found in territories of known boundaries were inside the territorial borders. However, they were often near the edge, or the male spent most of his time in an area to one side of the nest. Sprunt and Denton (in Griscom and Sprunt, 1957, p. 51) had this to say about the location of the nest in the defended territory:

> The territory defended by the male is used primarily for mating and feeding and not for nesting. The nest itself is usually located along the margin of the territory but may be entirely outside of it . . .

I wonder whether Sprunt and Denton's observations were not made during the incubation period when most males avoid the nest site, which is often near the edge of the territory, thus giving the impression of being outside it. When the eggs hatch, the male attends the young along with the female; then the territory no longer has a buffer zone.

The Swainson's Warbler builds a large and bulky nest (fig. 25), apparently larger than that of other warblers that nest above the ground. Of two nests, in Dismal Swamp, that I saw under construction from the beginning, one took 2 days and one 3 days to complete, and they were built entirely by the females. At one site the male was often close by but visited the nest no more than twice each day during the 3 days of construction; the male did not assist in construction and apparently visited the nest in search of the female. At the other site, during the initial stages of construction the male occasionally accompanied the female to the nest as she flew in with nesting materials; he brought along no material and left almost immediately after arriving at the nest.

At both these Dismal Swamp nests the female did virtually all of the building before noon. Building of the nest that I watched

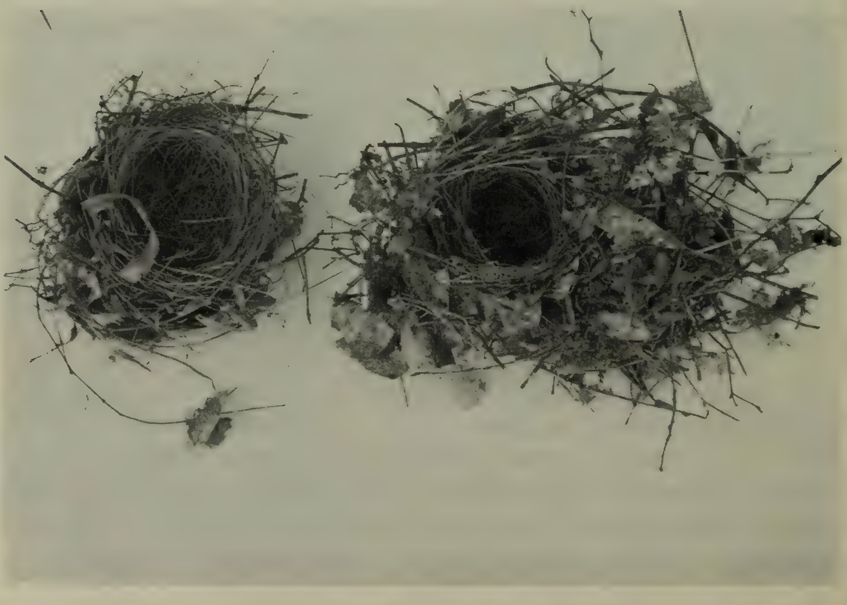


FIGURE 25.—The large, bulky nest of a Swainson's Warbler (right) and the nest of a nesting associate, the Cardinal, a species nearly twice the size of the warbler.

more closely took parts of 3 days, mostly between 7 and 11 a.m. Building was resumed in the late afternoon of each day between 4 and 5 p.m. However, during the late afternoon building period no more than half a dozen trips were made to the nest each day. The female made between 100 and 125 trips each morning. From 9:25 to 10 a.m. one morning, she made 34 trips, an average of about one trip a minute. During any sustained period she spent an average of 24 seconds at the nest, with a range of 9 to 70 seconds. The female sometimes chipped a few times while working on the nest. During the nest-building period, her mate rarely sang after 8 a.m.

All nest materials were gathered from the ground within 30 feet of the nest. Dry leaves, used in the bulky part of the nest and the outer layer, were obtained from the drier part of the woods; the cypress needles and red maple flower pedicels used in the lining came from a wet spot near the nest site.

Nests are constructed of a rather wide assortment of materials, but there is a selection of certain plant parts. The number of species of plants represented in a nest depends somewhat on the composition of the forest in which the nest is located. There seldom were more than a dozen species of plants in the nests I examined. The number of plant pieces in a Pendleton Ferry, Ark., nest totaled 418; there were 323 in a Dismal Swamp nest. The most pieces were in the lining of the cup. Sticks are seldom used in nests, and the few that occur seem almost incidental. But the first of three nests built by a female in a single season in the Dismal Swamp contained a great many sticks, which is the reason why it weighed more than the second and third nests.

In canebrakes the foundation of a nest is often a bunch of dead leaves that have lodged in the axils of a cane stalk. The Dismal Swamp female that built three nests used the relatively large leaves of the swamp magnolia as a platform for each of them. Each was at a site where several greenbrier vines crossed a horizontal limb of a shrub, so that the half dozen magnolia leaves formed a rather level base. Deposited upon these magnolia leaves were dried leaves, sticks, vines, and tendrils that formed the rather loose outer layer of the nest. Most of the leaves were swamp magnolia, red maple, red bay, and greenbrier. Most of the sticks were greenbrier.

The next layer was more compact, consisting almost entirely of decomposed or skeletonized leaves of the swamp magnolia. This layer formed the outer shell of a cup composed of finer materials in which the eggs were deposited. In positioning the leaf skeletons, their tips were drawn toward the rim at a gradually sloping angle to the curve of the cup. All of them were placed in a regular pattern, being drawn clockwise from near the base on one side of the cup to emerge and protrude from the rim almost at the opposite side. All of the protruding petioles thus pointed away from the circle of the rim at a narrow angle. This layer was constructed similarly in all three nests. Swamp magnolia leaves, being enlongated in shape, are well suited for this part of the nest structure.

Next to the layer of magnolia leaves was a layer of cypress twigs with needles. Cypress twigs and needles were also used as a lining for the upper inside half of the cup and for the rim of the nest. The lower inside half and bottom of the cup were lined mostly with pedicels of red maple flowers. All 11 of the Dismal Swamp nests were lined with these pedicels. Apparently they are a preferred item for the lining, since I have also found them in nests at Macon, Ga. F. M. Chapman (1907, p. 53) reports that J. N. Clark found them in linings of nests of the Worm-eating Warbler in New Jersey.

The Dismal Swamp female that built three nests in one season used fewer materials in constructing each succeeding nest; thus her nests were progressively lighter; dry weights were 47.7, 39.8, and 26.3 grams. Dimensions of an Arkansas nest were as follows: Greatest outside diameter, 15.0 cm.; inside diameter of cup, 4.0 by 5.0 cm.; outside depth, 7.8 cm.; inside depth, 4.2 cm.

EGG LAYING AND CLUTCH SIZE

At a Louisiana nest, there was a lapse of 2 days between the completion of the nest and the laying of the first egg; at a Dismal Swamp nest there was a lapse of 4 days. Eggs were laid daily until the clutches were complete, and incubation began with the laying of the last egg in each. At one Dismal Swamp nest the eggs were laid in the morning before 7 a.m. By marking eggs, incubation period at a nest at Augusta, Ga., was determined to be 14 or 15 days (J. Fred Denton, personal communication). The incubation period of eggs in a nest in the Dismal Swamp in 1969 was 13 days (F. C. Burford, personal communication). The first egg of this clutch of four was laid on May 1, and an egg was deposited daily; the first egg was hatching at 6:30 a.m. on May 17.

Of six first clutches in nests in Georgia, four consisted of three eggs each and two had four eggs. Of second clutches in four nests in Dismal Swamp, three had two eggs and one had three. The somewhat globular eggs are white (fig. 26), but slightly spotted eggs are found on rare occasions (Wayne 1910, p. 149).

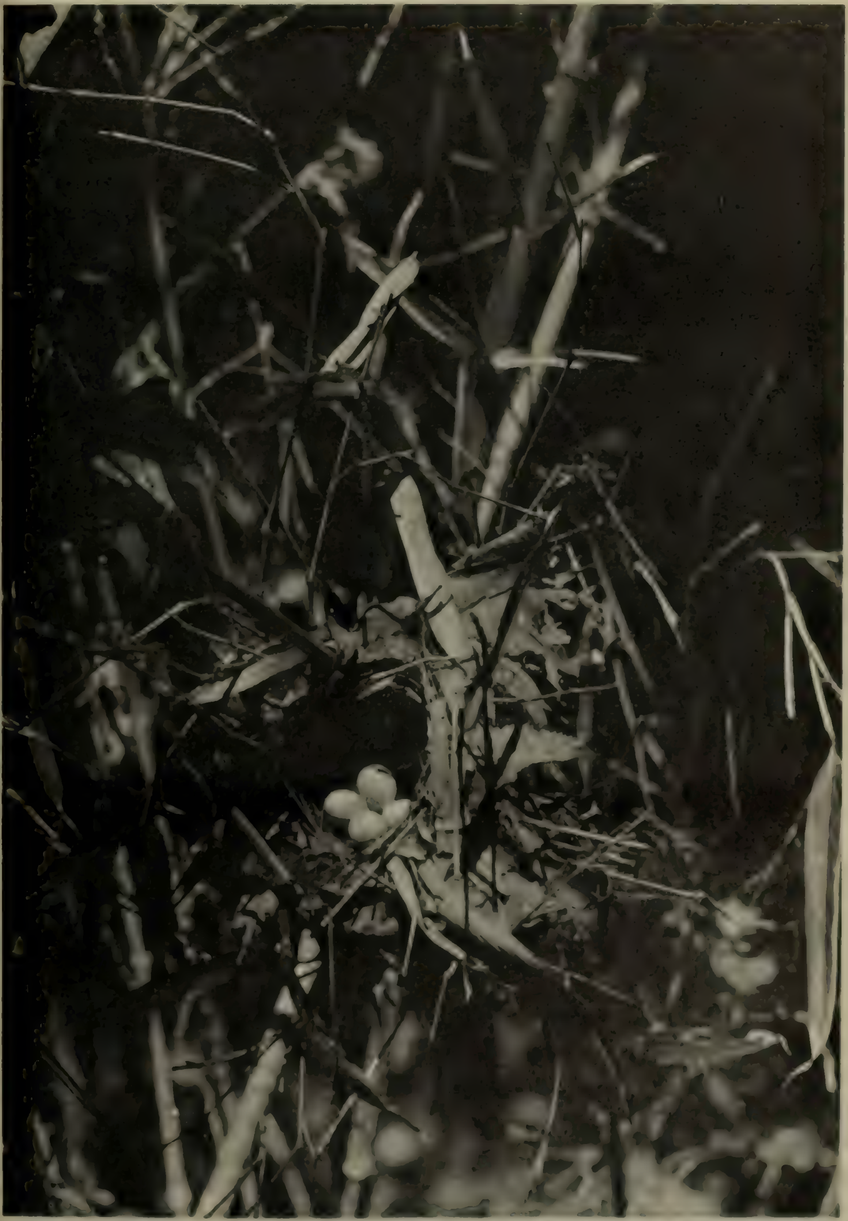


FIGURE 26.—Nest and eggs of the Swainson's Warbler in cane.

Cowbird parasitism

In some parts of its breeding range the Swainson's Warbler may be rather heavily parasitized by the Brown-headed Cowbird. During the first week in May 1967 at Pendleton Ferry, Ark., I located three Swainson's Warbler nests, all of which were parasitized. At one of the nests the warbler was incubating three cowbird eggs and one of its own. Three days later it was still incubating, but one of the cowbird eggs and its own egg were missing. At another one of the nests a warbler was incubating a single cowbird egg, and at the third a warbler was incubating three cowbird eggs; evidently the warbler eggs had been removed by the cowbirds.

Kirn (1918, p. 97–98) reported several parasitized nests in Copan County, Okla.; Sims and DeGarmo (1948, p. 5), in the course of 3 years, found three of 18 nests parasitized at Charleston, W. Va. I found that none of 11 Dismal Swamp nests were parasitized. Dismal Swamp is near the northern limit of the southeastern breeding range hiatus of the cowbird (Webb and Wetherbee 1960, p. 83–87), and I found only two or three cowbirds during an entire day in the Swamp in the spring of 1968. From 1944 to 1946 at Macon, none of six nests were parasitized, since at that time the area was out of the cowbird breeding range. By 1960, however, cowbirds were commonly breeding there.

INCUBATION

Information on behavior during the incubation period was obtained from a nesting pair in the first week of May at Pendleton Ferry, Ark., and from a pair in the Dismal Swamp in the middle of June. The Pendleton Ferry pair was the one mentioned above whose nest contained three cowbird eggs and one warbler egg. The nest was located about 2 feet above the ground between two cane poles. The height of the Dismal Swamp nest was also about 2 feet, and it was placed in a greenbrier vine. At each nest, incubation was performed only by the female.

During incubation the Pendleton Ferry female spent about 78 percent of her daylight time on the nest. The average period on the nest was 70 minutes; the average period off was 19 minutes. The longest period on the nest was 110 minutes, and the shortest was 30 minutes. The longest period away from the nest was 25 minutes; the shortest was 15 minutes. The Dismal Swamp female averaged 54 minutes on and 15 minutes off the nest. Lawrence (1953, p. 138), summarizing studies of six wood warblers, found that the birds were at the nest 67 to 83 percent of the time.

The two females I observed always sat in the same positions when incubating. Each left the nest each time in the same direction and fed in the same general area. The Pendleton Ferry female fed as far as 75 yards from her nest, but usually only about 30 yards from it. She fed both alone and with her mate. On one occasion her mate, which had not sung for more than an hour, flew to within 50 feet of the nest and sang two songs. The female chipped and left the nest, and the two flew off together to feed. Sometimes on leaving the nest the female flew out to about 30 yards from the nest where she chipped several times, presumably to attract her mate.

Upon returning to the vicinity of her nest, each female invariably chipped two or three times just before settling down.

The Dismal Swamp female was often fed by her mate when she left the nest during the incubation period. She followed the male on the ground like a fledgling following its parent. The male, walking about with cocked tail, gathered food and presented it to her.

During the several days of my observations, the Pendleton Ferry male never visited the nest. He did not come closer than 40 feet and usually stayed more than 100 feet distant. The Dismal Swamp male once, while the female was off feeding, visited the nest briefly and, not finding the female there, flew off and began singing vigorously. At dusk the Pendleton Ferry male was usually seen closer to the nest (40 to 50 feet) than during the lighter part of the day. He fed and sang in all areas surrounding the nest but was seldom closer than 50 feet. He did not sing as much as an unmated male in an adjacent territory.

CARE OF NESTLINGS

Most of my information on the care of nestlings is based on observations made during a 7-hour period on July 7, 1967, in the Dismal Swamp. Between 9:45 a.m. and 4:45 p.m. the 3-day-old nestlings were fed 14 times, eight times by the male and six by the female. The intervals between feedings ranged from 9 to 59 minutes. The female was at the nest 53 percent of the time brooding the young and sometimes standing on the rim. If she was brooding when the male came to the nest, she moved to the rim while he fed the young. Only the male removed fecal sacs from this nest, although at a Macon, Ga., nest the female also removed fecal sacs, sometimes swallowing them.

The male always approached from the same direction and worked his way slowly through the undergrowth until he was 2 to 3 feet beneath the nest; then he hopped up to the rim. The female approached from various directions, and flew 20 to 30 feet directly to the rim of the nest. On three occasions the male and female departed from the nest at the same time. Each time they flew in different directions.

Sims and DeGarmo (1948, p. 5) found that at several West Virginia nests young left after 10 days of nest life. At Augusta, Ga., the young remained 12 or more days in their nests (Griscom and Sprunt 1957, p. 53). Young that I observed at Macon, Ga., fledged at 10 days.

CARE OF FLEDGLINGS

Fledglings of a Dismal Swamp brood, just 2 days out of the nest, were fed only by the female during my 2 days of observations (June 13–14, 1967). The male was usually within 100 feet of the young and sang much of the time. The three fledglings usually did not attempt to follow the parents, but stayed within a relatively small area where they waited for the female to return with food. Most of the time they were perched 6 to 12 inches from the ground in heavy cover. During one 2-hour period, two of the three fledglings remained close together (5 to 10 feet) within a 20-foot-square area; at other times they were 50 to 100 feet apart. Sometimes after being fed, a fledgling attempted to hop along after its parent, but was soon left behind as the parent flew off in quest of food.

The fledglings were fed an average of every 15 minutes. When returning with food the female would walk and hop, rather than fly, to the waiting young. The young, hearing the approaching female parent rustling through the leaf litter, would intensify their chipping as she reached a point about 20 feet from them.

On three occasions, just as the female was about to feed a fledgling, the male pounced on her. As related above, pouncing also occurs during the prenesting period after the birds have paired.

Voice

SONG

The song of the Swainson's Warbler is loud and ringing and of marked musical quality. As Dingle (in Bent, 1953, p. 36) states,

> The bird student who hears the song of Swainson's warbler as he sings in his wooded retreat is fortunate, for it is one of the outstanding warbler songs and, once heard, leaves a lasting impression upon the listener. At a distance it bears much resemblance to the songs of the hooded warbler and

Louisiana waterthrush. Close up, however, the appealing quality, lacking in the other two, impresses the listener strongly.

Songs of different individuals of the species vary. I have stood in one spot and heard the songs of five Swainson's Warblers, each distinctly different.

The song consists of three or four high introductory notes, all separated, followed by a phrase of four or five syllables uttered rapidly and slurred (Brooks and Legg, 1942, p. 82).

The songs of seven birds were analyzed from tape recordings made by W. W. H. Gunn (in Griscom and Sprunt 1957, p. 26–27) at Charleston, W. Va. Gunn's rendition is as follows:

> *tee-o tee-o (tee) whit-sut-say bee-o,* or *tee-o tee toot-sut-say bee-u,* or *whee-u whee whit-sut-say bee-o.*
>
> . . . they have loud ringing songs closely resembling those of the Louisiana Waterthrush both in tonal quality and phraseology. However, certain characteristic differences are evident: First, songs of Swainson's Warblers are noticeably shorter in duration, being composed of fewer syllables. Then too, the slow opening notes comprising the first part of the song differ markedly in phrasing between the two species, and although there is a remarkable resemblance in the second portion of the song, the Louisiana Waterthrush then typically goes on to add a final phrase missing from songs of Swainson's Warblers.

Gunn says that the duration of the Swainson's song is 1¼ seconds and that of the Louisiana Waterthrush's 1½ to 2 seconds.

At a distance the strongly accented slurred ending (the first note high in pitch, the second low) of the Hooded Warbler song is suggestive of the ending of the Swainson's Warbler song, and often is confusing.

Whisper song

Berger (1961, p. 169) defines the whisper song as "the soft inward rendering of the primary advertising song, with or without variations." Muted or whisper songs of the Swainson's Warbler are a continuous chatter or musical twittering that may go on for as long as 3 minutes. I have never noticed any resemblance to the primary advertising song; rather they sound more like the continuous chattering notes of Goldfinches *(Spinus tristis)* in the spring, but are more musical. I have also heard in the spring a chattering song of kinglets *(Regulus satrapa* and *R. calendula)* and Blue-gray Gnatcatchers *(Polioptila caerulea)* that sounded a bit like the Swainson's Warbler whisper song. In the floodplain forest canebrakes of the Ocmulgee River in Georgia in April, I have heard all four of these species rendering these notes at nearly the same time. There have been times when I was not sure whether I was hearing a Swainson's Warbler whisper song or notes of the other three birds. In fact, the whisper songs of several species of warblers sound alike. I have been fooled by the Prothonotary Warbler and the Yellowthroat *(Geothlypis trichas),* thinking I was hearing a Swainson's Warbler.

The whisper song is seldom audible beyond 30 feet. It is given throughout the breeding season. Mayfield (1960, p. 127) thought that the Kirtland's Warbler sang whisper songs mainly when other males were nearby. Morse (1967, p. 497) found that in the Parula Warbler *(Parula americana)* muted and incomplete songs were associated with a high level of aggression. I have heard the Swainson's Warbler give the whisper song when in the presence of other males, following a conflict at a territorial border, when alone on an isolated territory, and after pouncing on a female just as she was about to feed fledglings. I have heard the whisper song of the Swainson's Warbler most often when there was no other male or female of the species, or any other bird, nearby.

The whisper song may be delivered when the bird is standing or moving on the ground, perched on a limb, or in flight. I heard one male give the whisper song as he flew along about 2 feet above the ground for a distance of 50 feet. The whisper and primary advertising songs may be alternated: I observed a perched Swainson's Warbler that sang both, preening in between, and then hopped to the ground, alternating the songs while foraging.

Flight song

I have heard flight songs that had no resemblance to whisper or primary advertising songs. They were as loud as the primary advertising songs but continuous and run together, and they lasted as long as the flight. One singing bird took off from the ground in a spiralling flight to a height of about 35 feet; another flew from the ground at a 60-degree angle to a perch 40 feet up.

Incomplete song

Incomplete songs—songs without endings and songs consisting of only the first, second, or third notes—may be heard at any time during the breeding season. As mentioned above, incomplete songs are sometimes given following territorial bouts with neighboring males. They are often heard when a bird is startled or frightened. For example, a Dismal Swamp male alternately sang only one and then two notes when a Common Grackle *(Quiscalus quiscula),* a nest robber, invaded his territory.

SINGING BEHAVIOR

The primary advertising song is sung only by the male, and so are whisper songs, as far as I can ascertain. When singing the primary advertising song, the bird changes the position of its head more than that of its body. The body is only slightly angled upward from the silent perching position; the head is thrown back with the bill pointed upward at a sharp angle, although not quite perpendicular. (Bird artists who have attempted to portray a singing bird of this species have usually done so incorrectly.) The bird's head and body are not tilted upward when singing muted or whisper songs.

The Swainson's Warbler sings from the ground, and from trees, shrubs, vines, and logs, usually below 30 feet. I have heard a bird singing from a perch as high as 50 feet, but singing from such a height is very uncharacteristic.

Singing from the ground is usually sporadic, since it is done while hunting for food. The bird nearly always stops to sing when foraging along the ground, assuming virtually the same posture as when singing from a branch; sometimes it starts singing before coming to a complete halt. After a male has spent some time on the ground intermittently foraging and singing, he may fly to the limb of a tree, where he rests, preens, or continues singing.

During the first few days after they arrive on the breeding grounds, birds in the canebrakes of the Ocmulgee River floodplain forest sing much more often from the ground than from trees or shrubs. In 40 hours of observation, three of four individuals were observed to sing only from the ground during their first week, April 12–19, 1965. During April 12–15, 1966, soon after the birds had arrived on the breeding grounds, one male sang only from the ground when under observation for 10 hours. When I next observed this bird, on April 28, it sang also from trees. Another male sang 135 songs from the ground and 65 from trees when under observation for 90 minutes on April 15.

When the Swainson's Warbler sings from trees, some of the perches most often used are dead branches well out from the trunk in the lower parts of the trees. The bird sings from a stationary position when perched in a tree or shrub, as pointed out by Brewster (1885a, p. 73–74):

> While singing he takes an easier posture, but rarely moves on his perch. If desirous of changing his position he flies from branch to branch instead of hopping through the twigs in the manner of most warblers.

However, a singing bird may reverse its position on the same perch and resume singing while faced in the opposite direction.

In the course of 1 hour a Charleston, W. Va., male sang from 18 perches, once only from each of 17, and five times from one.

In the Dismal Swamp on June 3, 1966, a Swainson's Warbler shifted from perch to perch during the first half hour or more of the morning song. The bird started singing at 4:27 a.m. It sang from the first location for 11 minutes, from the second for 10 minutes, from the third for 10 minutes, from the fourth for 4 minutes, from the fifth for 1 minute, and from the sixth for 1 minute. It began feeding and singing from the ground at 5:15 a.m.

Seasonal song cycle

The song period in the breeding range lasts from 5 to 6 months, depending on locality, but the most vigorous singing occurs during April and May. Males still mated in June and July sing almost as frequently as earlier in the breeding season. Singing is fairly regular but mostly in the morning until about August; it is sporadic from mid-August to mid-September when birds begin to leave the breeding grounds.

In floodplain forests of the Ocmulgee River in Georgia and the Arkansas River in Arkansas, I heard individuals singing daily in July and August. On August 6, 1966, during a 2-hour period (11 a.m. to 1 p.m.) when I was in a canebrake near Pendleton Ferry, Ark., a male sang 93 songs. In this same area on September 7, 1968, four males sang sporadically in the morning until about noon. They sang complete, incomplete, and whisper songs. Much of their singing was instigated by Carolina Wrens, which are among the loudest songsters of the southern woods.

The male sings vigorously following arrival on the breeding ground and until the pair bond is formed. Then, while traveling with and courting his mate during the prenesting period, he sings very little. Most of the singing is during the first 2 or 3 hours after daylight. After 7:30 or 8 a.m. during this period males may sing only half a dozen songs during the rest of the day. Such songs later in the day are usually for the purpose of rallying the mate.

During nest building, singing may be sporadic, and often very little singing is done. The male may sing infrequently in the morning while the female is working on the nest, but in the afternoon when nest building is at a virtual standstill the pair remains together and the male sings hardly at all. On the first day of nest building, a Dismal Swamp male sang only one cadence, of 7 seconds, between 9 a.m. and 6 p.m. The next day he did not sing at all after 9 a.m.

During incubation the male sings more often than during the courtship, mating, and nest-building periods. One of the functions of song during incubation appears to be to let the female know of her mate's whereabouts. I assume this, since the incubating female, upon leaving the nest, often goes to the male, with whom she feeds.

Singing during the nestling period is sporadic, since the male assists in the feeding of the young; after the young leave the nest, apparently only the female attends them, and the male increases his singing. During a 2-hour period (10:30 a.m. to 12:30 p.m.) when a Dismal Swamp female was attending her fledglings, the male sang a course about once every 10 minutes. After destruction of its mate's first nest, another male sang vigorously throughout the day and moved about the territory much more than usual; the female became very quiet and avoided the male, although she remained in the territory.

Daily pattern

The daily singing schedules of the Swainson's Warbler and other passerine woodland birds are about the same. In the Ocmulgee River forest the first singing of the Swainson's Warbler and other woodland birds was noted on a mild, cloudy morning, April 14, 1966. Sunrise was at 6:07 a.m. The first bird that sang was a Cardinal at 5:25 a.m., followed by a Rufous-sided Towhee at 5:32, a White-throated Sparrow *(Zonotrichia albicollis)* at 5:33, a Wood Thrush *(Hylocichla mustelina)* at 5:35, and then two Swainson's Warblers at 5:47. The Swainson's was the first warbler to sing, followed by a Prothonotary Warbler at 5:55 a.m. and a Hooded Warbler at 5:57 a.m. Almost all species of woodland birds were singing by 6 a.m.

In one of my study areas in the Dismal Swamp on June 3, 1966, the first Swainson's Warbler sang at 4:27 a.m., following a Cardinal, Wood Thrush, Wood Pewee *(Contopus virens)*, Crested Flycatcher *(Myiarchus crinitus)*, Hooded Warbler, and Tufted Titmouse *(Parus bicolor)*, all of which began singing after 4:05 a.m. Sunrise was at 4:44 a.m.

On April 14, 1966, in the Ocmulgee floodplain forest, two Swainson's Warblers with adjoining territories stopped singing at 7 and 7:14 p.m. On June 2, 1966, in the Dismal Swamp, a Swainson's Warbler sang until 6:45 p.m. Only the Wood Thrush, Cardinal, and Wood Pewee sang later in that section of the woods. Sunset was at about 7:28 p.m.

Rate of singing

A song is sung in a course or series, that is, a period of steady singing for several minutes at a time. Sometimes in the early morning the pause between courses is so brief that they seem to run for half an hour or more. Norris and Hopkins (1947, p. 8) noted that the average interval between songs of a male at Tifton, Ga., was 10.7 seconds.

The rate of singing is usually faster at the beginning of a course of songs (see table 3). During the first hour of morning song on June 2, a Dismal Swamp male sang at a fast but gradually diminishing rate of speed: nine songs per minute for the first 8 minutes, and five or six per minute thereafter.

The rate of singing is sometimes relatively constant over long periods of time. A male in the Ocmulgee floodplain forest on April 19 sang between 40 and 46 songs (40, 42, 46, 43, 42) in each 15-minute period from 8 to 9:15 a.m. Table 4 shows songs per 15-minute interval by a male in the Dismal Swamp.

TABLE 3.—*Songs per minute in courses by a territorial male Swainson's Warbler*

[4:15 p.m. to 6:43 p.m., 15 June 1966, in the Dismal Swamp in Virginia. Data from Meanley, Wilson Bulletin, 1968, p. 75]

Minutes in course	Time	Songs in each minute
5	4:15–4:20	8, 5, 5, 3, 2.
5	4:27–4:32	8, 6, 5, 2, 4.
6	4:40–4:46	7, 7, 7, 4, 4, 4.
13	4:50–5:03	8, 6, 4, 5, 5, 4, 5, 6, 6, 5, 5, 4, 1.
12	5:13–5:25	9, 6, 5, 4, 5, 4, 4, 4, 3, 4, 4, 2.
5	5:26–5:31	5, 5, 5, 6, 5.
3	5:48–5:51	8, 4, 1.
2	6:14–6:16	5, 5.
5	6:33–6:38	7, 5, 3, 4, 2.
3	6:40–6:43	5, 6, 4.

TABLE 4.—*Number of songs per 15-minute interval of a territorial male Swainson's Warbler*

[Observation made 3 June 1966, at Dismal Swamp, Nansemond County, Va. Sunrise about 4:44 a.m., sunset about 7:28 p.m.; sunny most of day; first song at 4:27 a.m.; sang until 6:45 p.m. previous evening. Data from Meanley, Wilson Bulletin, 1968, p. 76]

	Songs in 15-minute period ending at —					
Hour beginning at—	15 min.	30 min.	45 min.	60 min.	Total songs in hour	Temperature in woods (° F.)
4 a.m.	0	27	84	75	186	42
5 a.m.	61	33	50	48	192	47
6 a.m.	52	51	44	47	194	51
7 a.m.	54	53	48	43	198	52
8 a.m.	38	47	35	35	155	59
9 a.m.	24	23	29	0	76	61
10 a.m.	0	0	0	0	0	67
11 a.m.	0	0	0	0	0	67
12 noon	0	0	0	0	0	69
1 p.m.	0	0	1	0	1	68
2 p.m.	0	25	7	3	35	70
3 p.m.	8	21	12	31	72	70
4 p.m.	21	1	20	17	59	69
5 p.m.	0	0	0	0	0	62
6 p.m.	0	0	0	0	0	60
7 p.m.	0	0	0	0	0	55
Total in day					1,168	

Cadence of delivery

As pointed out by Reynard (1963, p. 139), an additional feature of bird song "unconsciously recognized but not particularly noticed is the cadence of delivery." Reynard defined the cadence of delivery of a song as—

> the average length of time from the first note of a song unit to the first note of the succeeding unit throughout the whole song performance. The period timed includes that in which the song unit is heard *and the silent period between song units.*

I recorded cadence of delivery of three territorial males on May 2 in the Dismal Swamp between 7 and 8 a.m.: the deliveries recorded were 20, 20, and 14. The average cadence for the sample was 13.7 seconds. Reynard (1963, p. 141–142) lists the cadence of song delivery of several other parulids as follows: Yellow Warbler *(Dendroica petechia)*, 11.2 seconds; Prairie Warbler, 12.9 seconds; Ovenbird, 21.2 seconds; and Hooded Warbler, 9.8 seconds.

Some of the factors that influence the rate of singing are the stage of the reproductive cycle, time of day, and degree of excitement. During the nest-building period one male Swainson's Warbler had an extremely rapid cadence of 4 seconds early in the morning (at 6, 6:30, and 6:35 a.m.). He was signaling his mate, which at the time was building the nest. The course, or series, was short in each case, containing only four to six songs. On each of the three occasions, the female discontinued nest building and flew to her mate, a distance of about 100 feet.

Comparison with associates

On hot June days in the Dismal Swamp, I found the Swainson's Warbler to be one of the most frequent singers in the woods if it had an active nest or fledged young in its territory. The Red-eyed Vireo *(Vireo olivaceus)* sang more continuously, but its song did not stand out like that of the Swainson's Warbler. In the early afternoon when song activity is generally at a minimum for most birds, the Swainson's Warbler often was the most persistent singer. On July 8, 1967, a Swainson's Warbler was the only species that I could hear singing during a driving rainstorm.

I have to disagree generally with Brewster (1885a, p. 72) who says that the Swainson's Warbler is a "fitful and uncertain singer" and that "you may wait for hours near his retreat, even in early morning, or late afternoon, without hearing a note." I have noted such behavior in many species of birds, but it may result from particular conditions at the time of observation. If one visits a Swainson's Warbler territory daily in the early part of the breeding season before pairing, it will soon be observed that this warbler sings as frequently as most of the other woodland birds. Frequency of singing, as pointed out above, depends on the stage of the breeding cycle, the time of day, and the meteorological conditions, among other factors. Between the formation of the pair bond and nesting, they sing very little.

ALARM OR CALL NOTE

Next to the primary advertising song, the *chip* or *tchip* note, given by both sexes, is the best known vocalization of the Swainson's Warbler. The *chip* note is sharper than the similar note of the Kentucky Warbler, an associate in much of the Swainson's Warbler breeding range. To me, the Swainson's Warbler *chip* is most like the *chip* of the first or last note of the song of the White-eyed Vireo. The two species occur together in the Coastal Plain Province, and I often have been fooled by the Vireo. However, it is not long before the Vireo reveals its identity as it follows through with the rest of the song or starts singing after giving the sharp *chip* note. Brooks and Legg (1942, p. 83) thought the Swainson's Warbler *chip* similar to that of the Mourning Warbler.

The chip call is used during intraspecific territorial strife, when alarmed by such nest robbers as snakes, Blue Jays *(Cyanocitta cristata)*, and Common Grackles, and as a call-note for members of a pair.

A variation of the chip note is used by the female during the mating period (see section on Courtship and Mating). In this case the notes may be softer and more musical, and they are run together, almost forming a chatterlike song.

Another vocalization uttered by both sexes resembles the *zeep* note of various species of warblers during fall migration. I have heard Swainson's Warbler give this note in September when still on the breeding territory. On April 28 in the Dismal Swamp, 3 days before nest building, I heard a female utter a soft *zeep* each time her mate sang. The note was so weak and the male so far from her that I am sure he seldom heard it.

Feeding Behavior and Food

FEEDING BEHAVIOR

The Swainson's Warbler is primarily a ground feeder, but it sometimes searches for food a few feet above the ground in undergrowth. It also forages along the top sides of logs that are lying on the ground, and it may fly to the side of a tree trunk to pick off an insect that is a foot or so from the ground. Sometimes it reaches or hops up a few inches from the ground to take insects from the undersides of leaves of low-growing herbaceous plants, and occasionally it flies from perches in the lower parts of trees in pursuit of insects. Large insects are held in the end of the bird's bill and beaten against the ground until broken into several pieces.

The Swainson's Warbler searches for food in a manner different from that of other ground-feeding parulids that I have observed. Insects are located mainly as the bird pokes its bill under leaves or piles of leaves, pushing them upward and searching the ground beneath or examining the undersides of the leaves. A leaf may be held up momentarily and tilted at an angle as the bird inspects the underside. If part of a leaf is curled, the upper and the lower mandible of the bird are parted to uncurl it. Sometimes, as the bird moves hurriedly forward lifting and shoving leaves from side to side, its entire body disappears beneath the leaves. Most of the Swainson's Warblers that I collected in the course of their food searching in the Ocmulgee River floodplain forest had their bills caked with mud.

The bill of the Swainson's Warbler is larger and sharper pointed than the bills of the Ovenbird, the Louisiana Waterthrush, and the Kentucky Warbler, ground-feeding parulids that in the generally level terrain of the southern floodplain forest obtain their food primarily from the surface of the leaf litter. The Kentucky Warbler works across the forest floor, often under a partial cover of low herbaceous vegetation such as wood-nettle, jewelweed (*Impatiens* sp.), or poison-ivy *(Rhus Toxicodendron)*. It hops along, flushing insects and picking them off stems and from beneath leaves of low-growing plants, and pokes its bill into piles of leaves or sticks. The Ovenbird (a walker) feeds similarly, but more in the open, as does the Louisiana Waterthrush (also a lker), which feeds about wet leaf litter and shallow pools and casionally does some leaf-flipping, in contrast to the shoving ide and "plowing" of the leaf litter by the Swainson's Warbler. e Swainson's Warbler also obtains some food from the surface the leaf litter.

Within a breeding territory, a male usually uses several, perps half a dozen, foraging areas on the ground to which it nsistently returns. Such areas are usually less than 50 feet uare and free of obstructions at and just above ground level. In e Georgia canebrake I observed a male for 30 minutes as it arched for food in one of these special feeding sites measuring by 30 feet.

When foraging in the shrub strata or undergrowth, the Swainn's Warbler probes into clusters of dead leaves and the axils of ne plants, as is typical of the Worm-eating Warbler, a species hich closely resembles the Swainson's Warbler in size and pluage and often occurs in the same place.

ill wiping

After feeding, a Swainson's Warbler mounts a limb and, before eening, spends a number of seconds wiping its bill. Bill wiping esumably is done to remove caterpillar hairs or other insect arts and pieces of dirt. The Swainson's Warbler has a good rean to spend more time wiping its bill than most other parulids ecause of its continuous probing beneath the leaf mantle in moist wet silty soil.

OOD

A total of 11 Swainson's Warbler stomachs have been examined biologists of the U. S. Department of the Interior. All were om birds collected in Alabama and Georgia canebrakes. These aminations indicate that the Swainson's Warbler is totally inctivorous. Among favorite food items typically occurring beeath the leaf mantle are crickets (Gryllidae), ground beetles Carabidae), ants (Formicidae), and spiders (Arachnidae).

Caterpillars (Lepidoptera) occurred in five of six stomachs llected in May and June in Alabama and were the most imortant by volume in four; ground beetles were the principal food em in one; and hymenopterous insects (probably ants) were ost important in one. Spiders occurred in three of the stomachs.

The following items, in order of volume, occurred in stomachs f two birds taken at Macon, Ga., in May: ground beetles, caterillars, stinkbugs, (Pentatomidae), homopterous insects (Homopra), silken fungus beetles (Nitidulidae), and beetle larvae.

Crickets formed 43 and 40 percent by volume of the stomach contents of two birds collected near Augusta, Ga., in September; other major items in the two stomachs were Acrydiinae (grasshoppers), ichneumids, ants, and spiders. A stomach taken at Augusta in August contained the following items: 13 insect or spider eggs and the mass of silky material covering them, 16 ants, two ground beetles, three unidentified beetles, seven undetermined insect larvae, one caterpillar, one millipede (Diplopida), one stinkbug, one rove beetle (Staphylinidae), one darkling beetle (Tenebrionidae), and one beetle larva.

Near Cienfuegos in Cuba, Eaton (1953, p. 172) collected several Swainson's Warbler stomachs that contained the bones of small lizards (Iguanidae). He also found such bones in the stomachs of Worm-eating Warblers and Ovenbirds.

Miscellaneous Notes on Behavior

GROUND LOCOMOTION

The gait of the Swainson's Warbler is different from that of any other ground-feeding parulid. In searching for food, usually in dry leaf litter, its gait is described by Brewster (1885a, p. 74) as "distinctly a walk." Norris (1963, p. 47) also observed that it walked, and that its "gait was rather rapid and jerky, suggestive of that of the starling." He further stated that the Swainson's Warbler may hop "when traversing leaf litter." After 25 years of observing this species for many hours each spring, I would say that it hops some of the time, though mostly it moves in a rather rapid step that is a sort of a cross between a walk and a hop, suggesting a canter.

In searching for food on the ground it moves along hurriedly, often turning from side to side, and sometimes making a complete turnabout (180°) in a single hop or jump.

Another characteristic peculiar to this species while foraging on the ground is the quivering or tremulous movement of the posterior part of its body which sometimes occurs. This is not just a tail movement, but a part of the lower trunk of the body also is involved. I have observed this movement in both sexes.

PREENING

"This species often sits and engages in preening and scratching—apparently more so than does any other warbler of my acquaintance." So writes Norris (1963, p. 47), a Georgia ornithologist who knows this warbler well. I once observed a male preening continuously for 7 minutes. They seem to do a lot of preening in the center of the breast; this behavior must be related to the method of foraging, wherein the breast constantly is coming in contact with leaves and soil.

HEAD SCRATCHING

Ficken and Ficken (1968, p. 136) have suggested that the "head scratching method may prove a valuable addition to the set of complex characters that can be used in defining genera." In the course of a series of observations of Swainson's Warblers in the Dismal Swamp in Virginia, I observed head scratching in three individuals: four times in one, three times in another, and once in a third. The three birds used the direct method, bringing the foot forward and under the wing. Ficken and Ficken (1968, p. 136) indicate that some *Vermivora* scratch directly and others indirectly and that all species of *Dendroica* observed in the wild scratched indirectly.

TAIL SPREADING

Tail spreading or fanning by a male may occur following territorial boundary disputes with another male. This is usually done by a male that invades another's territory and is driven out. I once saw a male on territory fanning its tail while being pursued slowly by a Redstart that had young in the territory.

Factors Affecting the Population

The Swainson's Warbler is the least abundant of southern warblers, except for Bachman's Warbler. There are several reasons why the Swainson's Warbler is not more successful. From my observations it would appear that it has a lower nesting success than most other species of warblers. In a total of 16 nests of which I am reasonably sure that my presence had nothing to do with desertion, only three were successful. Some of these were second attempts; others were initial attempts, in which case the birds may have been successful on the second try. At three of the nests, cowbirds removed all of the Swainson's Warbler eggs. A mouse expropriated another nest during the laying period, and two nests were abandoned with clutches intact.

Some of the reasons for its low nesting success may be the vulnerability of the large, bulky nest that is poorly concealed, is located close to the ground, and contains white eggs. Other species of warblers nesting in the same breeding range have better-concealed nests, most of which are much smaller, and all of which contain speckled eggs except the very rare Bachman's Warbler, which also has white eggs. Furthermore, most Swainson's Warbler nests are lined with dark material, so that the white eggs stand out against the dark background.

In the Dismal Swamp, I found that whenever a Common Grackle or a Blue Jay had a nest in or near a Swainson's Warbler nesting territory, the warbler's nest was almost always robbed. However, since the Grackle and Jay begin nesting before the Swainson's Warbler, and their nesting seasons overlap the first nesting attempt of these warblers, a second attempt can be made after the two nest plunderers have completed nesting and left the area.

Since the Swainson's Warbler places its not-too-well-hidden nest close to the ground, it is well within the "cruising" range of various snakes and mammals. C. E. Collier, Jr., (1941, p. 28) discovered a milk snake *(Lampropeltis triangulum)* in the act of robbing a Swainson's Warbler nest, near Clarksville, Tenn. The snake had one of the warbler's eggs in its mouth at the time.

Cowbird parasitism is becoming a more important limiting factor. Friedmann (1929, p. 150) and Mayfield (1965, p. 13–18) believe that the cowbird originated in the prairies and plains of the West, and only in the last 100 years or so invaded the eastern forest. As late as 1950 most of the southeastern Coastal Plain was outside the breeding range of the cowbird, but it is gradually extending its breeding range into that area (Webb and Wetherbee 1960, p. 83–87). The cowbird is a common breeding bird throughout the lower Mississippi Valley and Appalachian mountains nesting range of the Swainson's Warbler.

Since one of the choice nesting sites of the Swainson's Warbler in the Coastal Plain is the river floodplain forest, production is markedly limited when such areas become inundated during the nesting season. In the Ocmulgee River floodplain of central Georgia, virtually all of the Swainson's Warblers nest within half a mile of the river. This is where the canebrakes are located. Some of the birds nest right up to the river bank. I have seen some Swainson's Warbler territories that were under 12 feet of water. Three out of 10 years that I worked in this area the nesting ground was flooded during May when the Swainson's Warbler was nesting.

Calhoun (1941, p. 306) found a similar situation in the Hatchie River bottoms in Hardeman County, Tenn. He made the following statement about these conditions:

> If the Swainson's warbler nests in this same type of region, it would be exceedingly difficult to study its nesting habits because such areas are subject to flooding in the spring and early summer.

In the Coastal Plain part of its range the Swainson's Warbler would probably have a difficult time maintaining its present population level, not only because of low nesting success, but also because of its narrow habitat requirements. Canebrakes, prime habitat of this species, have disappeared faster than any other bottomland plant community. Habitat has disappeared faster in the lower Mississippi Valley than elsewhere in the range. Very early, rich bottomlands of the lower Mississippi Valley were stripped of their valuable hardwood timber and then cleared and drained for the agricultural use of their highly productive soils. Habitat in the Great Dismal Swamp and some other South Atlantic lowlands has contracted because the deep shade required by this species disappeared with the harvesting of the mature forest. The cut-over areas were drained and reforested with pine.

It is possible that the Swainson's Warbler can adapt to so-called marginal Coastal Plain habitat better than is suspected. Some occur there, but these usually are bachelor males. But if the Swainson's Warbler ever has to make a last stand it may well be in the Southern Appalachians, where many of them occur in national forests and national parks or in areas unsuitable for agricultural production.

Summary

The Swainson's Warbler is one of the least known of southern birds. Studies of its life history and ecology were made by the author principally in canebrakes along the Ocmulgee River a few miles south of Macon, Ga., and near Pendleton Ferry, Ark., in deciduous thickets in the Dismal Swamp, Va., in scrub palmetto in Monkey John Swamp, S.C.; and in mountain cove hardwoods near Charleston, W. Va.

The Swainson's Warbler was described by Audubon from specimens collected by John Bachman on the banks of the Edisto River in South Carolina in 1832 or 1833. John Abbot, a Georgia naturalist, collected a specimen some 25 years earlier but made no record of the event. However, he made an identifiable portrait of the bird. His illustrations of birds were discovered many years later in several museums.

The Swainson's Warbler spends nearly 6 months in the United States. During this period (summer half of year) it is primarily associated with the river floodplain forests and swamps of the South Atlantic and Gulf Coastal Plain and the rich moist woods of the Mixed Mesophytic forest of the Southern Appalachians.

The main wintering ground is the Caribbean archipelago in the general latitude of 20° N., especially the islands of Jamaica and Cuba; individuals also winter in the Yucatan Peninsula and British Honduras.

Some migrants apparently fly across the Gulf, some around it. First spring migrants reach the southern coast of the United States usually by the last half of March or the first week in April. Most birds are on the breeding grounds by April 15, but some arrive by the first week in April. In the fall most have departed from the breeding grounds by September 15.

The optimum habitat is rich damp woods with deep shade, moderately dense undergrowth, and relatively dry ground. Giant cane, scrub palmetto, and sweet pepperbush are the most important plants of Coastal Plain breeeding grounds; rhododendron and cove hardwood shrubs are important in the mountains.

In April 1968, I counted 19 territorial males along a 2-mile transect through canebrakes near Macon, Ga. I found eight territorial males along a 0.5-mile transect in the Dismal Swamp in

Virginia, April 20, 1958. Brooks and Legg counted 10 or 11 singing males along 1.5 miles of Franzy Creek in Nicholas County, W. Va.

The Swainson's Warbler is 5 to 5½ inches in length, and during the breeding season weighs about 15 grams. Breeding birds of the Southern Appalachians usually have whiter underparts than Coastal Plains birds.

The Swainson's Warbler is one of the last of the southern warblers to arrive on the breeding grounds, but is earlier than most northern transient members of the family. One banded male returned to the same territory in Maryland for five consecutive breeding seasons.

Nine territories ranged in size from 0.3 to 4.8 acres. The size and shape of a territory varies during different phases of the breeding cycle.

Hostile encounters between neighboring males usually take place along territorial boundaries. Paired males usually initiate border encounters with unpaired males. A display is sometimes performed by an aggressive male after it is driven back into its territory.

During courtship and mating the male sings very little. Frequently he flies to the female, who usually is foraging on the ground, and either pecks at her rump or pounces on her. Copulation sometimes takes place during pouncing.

First nests usually are built by the first week in May. Although other investigators reported finding nests outside the defended territory, all nests that I found were within the territory. The large bulky nest of this species is usually placed 2 to 6 feet above the ground. It is built by the female from materials gathered close to the nest site; she takes 2 or 3 days to complete it.

Three and occasionally four white eggs are laid. At a Dismal Swamp nest the incubation period was 13 days. The cowbird parasitizes nests in some parts of the breeding range.

During incubation two females spent 54 and 78 percent of daylight time on the nest. Both sexes feed young and clean the nest. Young remain in the nest 10 to 12 days. Fledglings of one brood were attended only by the female.

The song of the Swainson's Warbler is loud and ringing and of marked musical quality. It consists of three or four high introductory notes, all separated, followed by a phrase of four or five syllables uttered rapidly, and slurred. Songs are delivered at a rate of about 8 or 9 per minute for the first few minutes of morning song, then decrease to 5 or 6 per minute for most of the morning. Songs are given in courses or series. The rate of singing is usually faster at the beginning of a course. The number of songs sung by a territorial male in 1 day, June 3, in the Dismal Swamp was 1,168. It produced 186 songs the first hour and sang at a fairly constant rate from 5 to 8 a.m., 192, 194, and 198 songs per hour.

Muted or whisper songs are a continuous chatter that may go on for as long as 3 minutes. They do not resemble the primary advertising song and may be given in the presence of other Swainson's Warblers or when alone. The alarm note is a sharp *chip*. A weaker chip is used for communicating during courtship.

The primary advertising song is sung from the ground and from perches at low elevations. The whisper song is usually given from the ground.

The Swainson's Warbler is primarily a ground feeder, but sometimes searches for food a few feet above the ground in undergrowth. Insects, its main food, are located as the bird pokes its bill under leaves, pushing them upward and examining the underside, and searching the ground beneath. Foods gleaned from beneath the leaf mantle usually are ground beetles, crickets, ants, and spiders. Sometimes caterpillars are taken in the course of foraging in the shrub strata.

The usual gait of the Swainson's Warbler is a cross between a hop and a walk, suggesting a canter. The direct method is used in head scratching, that is, bringing the foot forward and under the wing. Tail spreading or fanning by a male may occur following a territorial boundary dispute with another male.

The Swainson's Warbler is one of the least abundant of southern warblers. It has a low nesting success because its large bulky nest is poorly concealed, is located close to the ground, and contains white eggs. In parts of its range it is highly parasitized by the cowbird. In some Coastal Plain floodplain forests, nests are destroyed during floods.

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The Distribution and Occurrence
# of the
BIRDS OF JACKSON COUNTY,
REGON, AND SURROUNDING AREAS

by M. Ralph Browning
National Fish and Wildlife Laboratory
FISH AND WILDLIFE SERVICE

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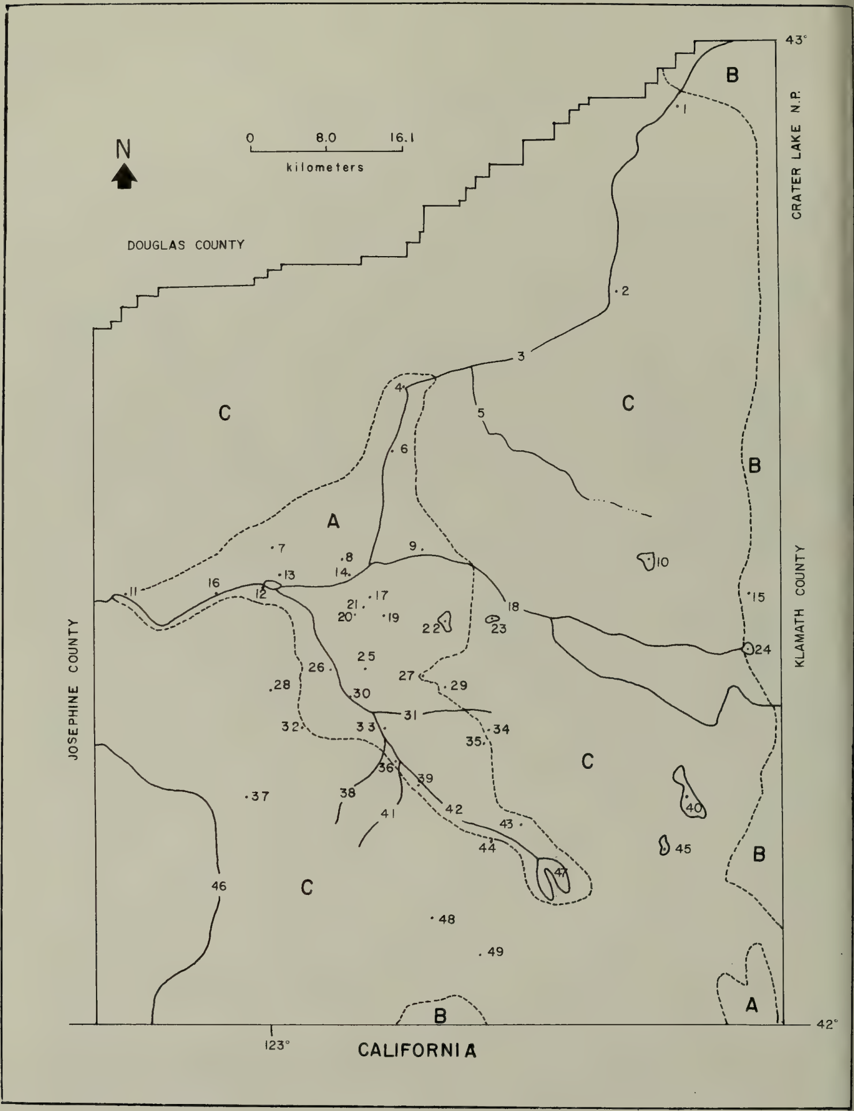
INTRODUCTION

ackson County in southwestern Oregon occupies 4,525 km^2. The nty is situated between 42°00′ and 43°00′ north latitude, and ween 122°17′ and 123°14′ west longitude. About 113 km from Pacific Ocean, the county is bounded by California to the south by the Oregon counties of Josephine, Douglas, and Klamath the west, north, and east, respectively (Fig. 1). About 95,000 ple live in Jackson County, most of them concentrated in the es of Medford and Ashland in Bear Creek Valley. The remaining ulation is chiefly scattered throughout the Lower Rogue River Bear Creek valleys. Agriculture (orchards, especially pears, and ed farmland) dependent on summer irrigation, light industry imarily lumber), and residential areas occupy most of the land area ow 610 m elevation in the Lower Rogue and Bear Creek valleys. out 70 percent of the county above 610 m is coniferous forest.

he distribution and occurrence of the Jackson County avifauna of interest because the county is a small geographic area with nerous plant communities. In the Rogue River Valley, a large iety of breeding species similar to the avifauna of areas of Cali-nia several hundred kilometers to the south was reported by brielson (1931). Since then six papers (Stevenson and Fitch 1933; hardson 1961; Richardson and Sturges 1964; and Browning 6a; 1966b; 1972) have dealt with certain birds of specific areas of county. Thomas McCamant compiled 10 years of field notes into unpublished checklist with specific data on his more significant ervations from 1947–57. The University of Oregon Press printed hecklist, "Birds of Southern Oregon," compiled at Southern Oregon llege by Franklin W. Sturges.

began field investigations in Jackson County in 1957. Since then ave visited most of the county and have conducted field observa-ns or collected in all areas listed in the gazetteer. From 1965 to 7 I attempted especially to explore previously uninvestigated ions of Jackson County. The Union Creek area (1965) and the theastern corner of the county (1966, 1967) were surveyed for eding species.

his report is based on information from the literature, specimens, otographs, unpublished notes of countless individuals, and my own estigations of Jackson County. Specimens cited in this report are the Carl Richardson Bird and Mammal Collection at Southern egon College, Ashland, Oreg.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TOPOGRAPHY

Jackson County occupies an inland trapezoidal area of approxi-ately 77.2 km east and west, 77.2 km north and south on the western oundary, and 108 km north and south on the eastern boundary. icken's (1959:12) landform regions of Oregon divide the county into wo major mountain systems, the Cascade and Siskiyou mountains, nd one primary drainage system, the Rogue River and its tributaries.

The Siskiyou Mountains, a part of the Klamath Mountain system, rm a dissected plateau more rugged than the Coastal Range of regon. This range, running from east to west in the southern end of he county, rises to elevations of over 1,524 m (Atwood, 1940:468). ount Ashland, elevation 2,296 m, is the highest peak in the Siskiyou ountains.

IG. 1. Jackson County, Oregon, showing the localities listed in the Gazeteer. Numerical order of the localities are from north to south and west to east.

1. Union Creek (town)
2. Prospect
3. Rogue River (stream)
4. Trail
5. Big Butte Creek
6. Shady Cove
7. Sam's Valley
8. Upper Table Rock
9. Eagle Point
0. Willow Creek Reservoir
1. Rogue River (town)
2. Gold Ray Dam
3. Lower Table Rock
4. Old Military Bridge
5. Mount McLoughlin
6. Goldhill
7. Agate Desert
8. Little Butte Creek
9. Hoover's Lakes
0. Game Ponds
1. White City
2. Agate Reservoir
3. Gardner Reservoir
4. Fish Lake
5. Medford Municipal Airport
26. Central Point
27. Roxy Ann Peak
28. Johns Peak
29. Oregon Switzerland
30. Medford
31. Larson Creek
32. Jacksonville
33. Voorhies Crossing
34. Mount Baldy
35. Tombstone
36. Phoenix
37. Ruch
38. Coleman Creek
39. Talent
40. Howard Prairie Reservoir
41. Anderson Creek
42. Bear Creek
43. Pompadour Bluff
44. Ashland
45. Hyatt Reservoir
46. Applegate River
47. Emigrant Reservoir
48. Wagner Butte
49. Mount Ashland

(A=Chaparral-Oak Community, B=True Fir Forest, C=Mixed Conifer Forest.)

Joining the Siskiyous in southeastern Jackson County, the Cascade Mountains run from north to south east of Bear Creek Valley and part of the Rogue River Valley. Near Union Creek the Cascades are differentiated geologically into the Old and High Cascades. The Old Cascades are in the western part of the system and are typically less rugged and of lower elevation than the High Cascades. Mount McLoughlin (elevation, 2,975 m) is the highest point in the more rugged High Cascades in eastern Jackson County.

The Rogue River Valley, a trough-like basin, constitutes the major flat lowland portion of the county. To differentiate the upper and lower sections of the Rogue River Valley, I use the term Lower Rogue River Valley to refer to that part of the valley downstream from Shady Cove (426 m) to the boundary of Josephine and Jackson counties (about 305 m). The Lower Valley extends north into Sams Valley near Upper and Lower Table Rocks. The narrow Upper Rogue River Valley extends from Shady Cove to above Union Creek. The remaining lowland area of the county is the Bear Creek Valley. Bear Creek and its tributaries form the main drainage of the eastern Siskiyous where that range joins the Cascades. This valley begins near Ashland (elevation, 610 m) and terminates at the Rogue River near Gold Ray Dam (366 m).

The Rogue River and Bear Creek are fed primarily by winter rains and melting snow in the higher elevations during summer. Bear Creek becomes almost intermittent during dry summer months, and many of the tributaries of the Lower Rogue River become low and sluggish. Most of the mountain tributaries above Shady Cove as well as the Rogue River are spring fed, and water levels are fairly stable. The Applegate River, a major tributary of the Rogue River with its headwaters in the Siskiyou Mountains, terminates near Grants Pass in Josephine County.

Numerous bodies of water, mostly irrigation reservoirs, are near the Cascade Mountain Crest. Among those of particular ornithological interest are Fish Lake and Howard and Hyatt Prairie reservoirs. At the head of Bear Creek Valley is Emigrant Reservoir. Where Bear Creek intersects with the Rogue River there are backwaters formed by Gold Ray Dam. Small lowland bodies of water north of Medford include a series of ponds known as Hoover's Lake another nearby series of ponds in the Ken Denman Game Management area of the Oregon State Game Commission here referred as the Game Ponds, and Agate Reservoir northeast of Medford.

CLIMATE AND VEGETATION

Temperatures in the county are usually mild. Summer is characterized by warm days and cool nights. Rainfall is primarily a winter phenomenon; during the drier summer months it is usually a product of local electrical storms. Summer days are usually cloudless and humidity is very low; less than 10% is not uncommon in the valleys and mountains. Most winter days are heavily overcast and fog is common in the Lower Rogue River Valley during most of December.

Climatic data are presented in Table 1. Data from Crater Lake National Park in Klamath County are included as representative of the southern Cascade Mountains in Oregon.

Precipitation in Jackson County varies in form and amount. The driest months at Medford are July, August, and September. Most of the rainfall (28 cm) at Medford occurs from November to February; December, the wettest month, has an average of 8.9 cm (Rudd 1962). The distribution of precipitation in the mountains of Jackson County is similar to that in Medford but is mostly in the form of snow.

The vegetation of Jackson County is best described in terms of forest coverage. Earlier concepts of vegetation distribution (see Bailey 1936) in the county recognized five life zones—Upper Sonoran, Transition, Canadian, Hudsonian, and Arctic-Alpine. Peck (1941) described nine vegetation areas for Oregon using a system that more closely approaches the plant community concept and allows a more ecological interpretation of a geographic area. A classification of plant communities adapted from Munz and Keck (1959) is used here to describe the vegetation of Jackson County (Fig. 1). The system adapted is

Table 1. *Climatic data from representative weather stations in Jackson County, Oreg.*

Station	Temperature (F)					Precipitation (inches)		Frost free days
	Average annual	Average January	Average minimum January	Average July	Average maximum July	Average annual	Average	
Medford	54	37	30	72	89	20	7	161
Prospect	50	35	26	66	88	42	64	--
Siskiyou Station	48	34	26	65	76	33	--	--
Crater Lake [1]	39	25	18	54	66	70	589	71

[1] Conditions for southern Cascades in Jackson County less extreme.

Source: U.S. Weather Bureau 1965, Rudd 1962, Farner 1952.

similar to that presented by Franklin and Dyrness (1973). Some of th departures between the system used here and that of Franklin an Dyrness (1973) are mentioned in the following discussion of plan communities of Jackson County.

Four plant communities occur in Jackson County. Scientific name of the vegetation are from Randall (1964).

Chaparral-Oak Community.—The Chaparral-Oak area of th Lower Rogue River and Bear Creek valleys is considered a probabl postglacial relict (Detling 1961) related to the California chaparra formation south of the Siskiyou Mountain barrier. In Jackson Count this area from the valley floor to about 762 m is more arid and ha hotter day-time temperatures than the surrounding areas. Land no under cultivation or uninhabited is dominated by island groves o *Quercus garryana* and *Q. kelloggii,* with an understory of *Ceanothu cuneatus* and *Arctostaphylos viscida. Ceanothus cuneatus* and *Arctostaphylos viscida* may be found throughout the valley and foothill growing in dense brushfields or mixed with *Quercus* groves. Much o the area is characterized by large open fields of dwarf grasses and short lived annuals that usually die by mid-June because of lack of precipitation. Such fields frequently stand under 2.5 cm or more of wate during winter.

The eastern Bear Creek foothills are characterized by larger an more abundant *Quercus* groves, scattered trees of *Pinus ponderosa,* an an understory of *Rhus diversiloba* (Fig. 2). Most of the southern an western slopes of Roxy Ann Peak and Baldy are dominated by nearl impenetrable *Rhus diversiloba,* often over 3 m high, interrupted onl

Fig. 2. Foothills east of Medford. *Quercus* groves and *Pinus ponderosa* are the predominate trees. *Ceonothus* and *Arctostaphylos* spp. occupy most of the foreground. Elevation, about 610 m.

by small *Quercus* groves and on Baldy by large open areas (balds), which include about 75% of the southern and western slopes above 762 m (Fig. 3).

The western valley foothills are cooler and less arid than those in the eastern part of the valley. Dominant vegetation includes *Quercus garryana, Q. kelloggii, Arbutus menziesii, Ceonothus* spp., *Rhus diversiloba*, and occasionally small *Pseudotsuga menziesii. Arctostaphylos viscida*, sometimes in very dense growth, may be associated with *Arbutus menziesii* in the western foothills as an understory. *Arctostaphylos* is a common dominant plant on the arid southern slope of the Siskiyou Mountains up to 1,219 m and along the base of Roxy Ann Peak.

Characteristic plants in southeastern Jackson County are similar to those in the Lower Rogue River and Bear Creek valleys. Primary differences are the greater abundance of *Pinus ponderosa* and *Pseudotsuga menziesii*. The avifauna of this region is more characteristic of the Lower Rogue River and Bear Creek valleys.

Riparian growth, included here with the geographic area encompassed by the Chaparral-Oak Community, occurs along the Rogue and Applegate rivers, Bear Creek, and some of their tributaries. Characteristic vegetation includes *Salix* spp., *Populus trichocarpa, Fraxinus latifolia*, and *Rubus* spp. understory.

The remaining portion of Jackson County is mountainous and dominated by coniferous forest. This upland part of the county is in the Oregonian Province (Dice 1943:31), which includes the Cascade Mountains of northern Jackson County west and north of Union Creek

Fig. 3. *Quercus* groves and diversified farmland east of Medford. *Ceonothus* spp., *Rhus diversiloba*, and oak groves on the west slope of Mount Baldy are interrupted with open areas of short grasses and annuals.

and most of the southern part of the county occupied by the Siskiyu
Mountains.

Three plant communities occupy the remainder of the county:

Mixed Conifer Forest.—*Abies, Pinus,* and *Pseudotsuga* are do
nant trees in the Mixed Conifer Forest occupying an elevational ra
of 762 to 1,372 m. *Pseudotsuga menziesii* occurs in most locati
(Fig. 4). Most of the area has been heavily logged. *Pinus ponder*
Pseudotsuga menziesii, Libocedrus decurrens, Pinus jeffreyi (Siski
Mountains), *Thuja plicata, Arbutus menziesii, Quercus garryana,*
kelloggii are dominant species. *Quercus* spp. occurs with *Pinus p*
derosa in the lower elevations and most commonly in the extre
southeastern region of the county. Mixed forest of *Pinus* sp
Pseudotsuga menziesii, Tsuga heterophylla, Abies grandis, A. nobi
and *A. concolor* are dominant from about 1,219 to 1,372 m (Fig.

Pinus ponderosa and *P. lambertiana* (mostly secondary grow
associated with *Pseudotsuga menziesii* are dominant along the Up
Rogue River between Shady Cove to Prospect and east of Un
Creek. *Pinus lambertiana* and *Pseudotsuga menziesii* are domina
from Prospect to Union Creek.

Fig. 4. *Pseudotsuga menziesii* on the western slope of the Cascade Mountains
Mixed Conifer Forest.

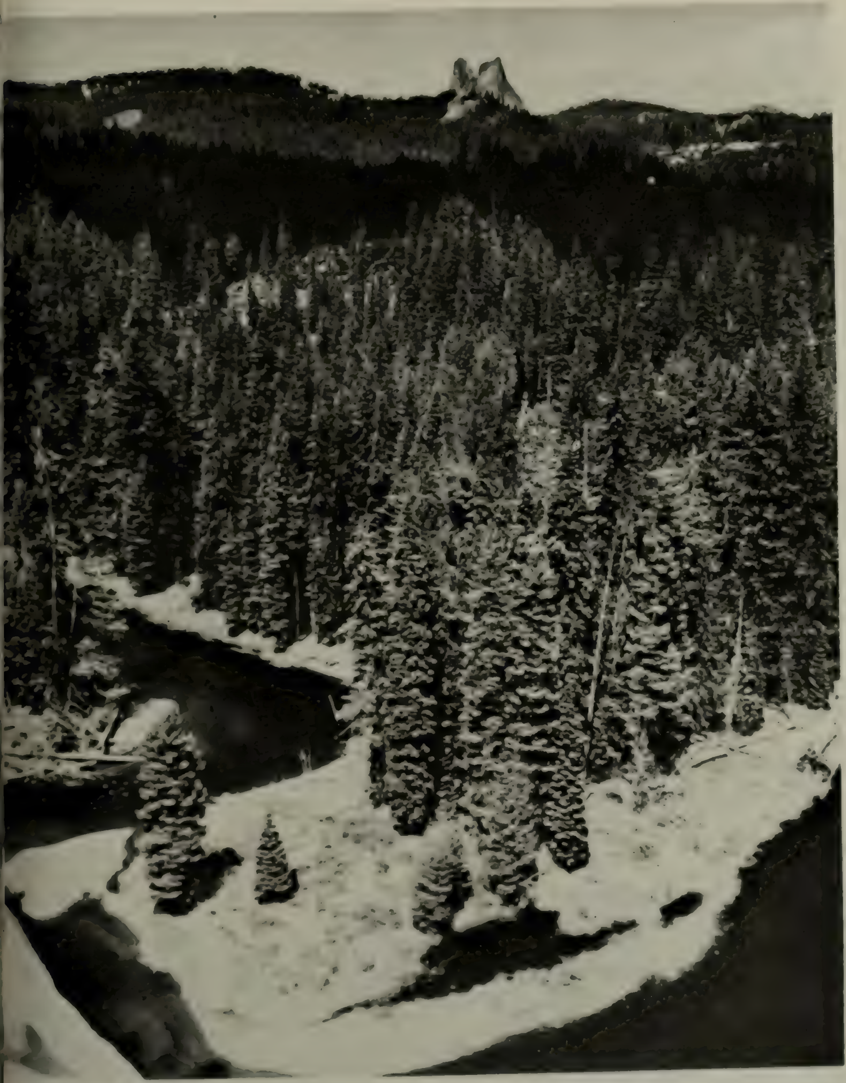

Fig. 5. Mixed Conifer Forest north of Union Creek at 1,219 m.

Franklin and Dyrness (1973) differentiated this community into two zones. The western Siskiyou Mountains are considered to be in the Mixed-Evergreen (*Pseudotsuga*-Sclerophyll) Zone. The most dominant tree species are *Pseudotsuga menziesii* and *Lithocarpus densiflorus*. The west slope of the Cascades and the eastern Siskiyou Mountains are considered in their Mixed-Conifer (*Pinus-Pseudotsuga-Libocedrus-Abies*) Zone, which includes as dominant trees *Pseudotsuga* *menziesii, Pinus lambertiana, P. ponderosa, Libocedrus decurrens,* an *Abies concolor.* Ornithological investigations in these areas, especiall the Siskiyou Mountains, are insufficient to compare the ecologica aspects between these two plant communities.

True Fir Forest.—True firs occupy a narrow band of the Cascad Mountains above 1,372 m to about timberline (Fig. 6). Dominan species are *Abies magnifica shastensis, A. concolor,* and *A. procera* Associated species are *Tsuga mertensiana, Pinus contorta, Sorbus occidentalis,* and *Viburnum pauciflorum. Abies magnifica shastensis* is dominant species in the Siskiyou Mountains (Fig. 7) from about 1,79 to 2,012 m (Waring 1969).

Timberline Forest.—The highest elevations of Jackson Count are typically forested by small subalpine forests; two Cascad Mountain peaks (Mount McLoughlin and Brown Mountain) ar above timberline (Fig. 6). *Pinus albicaulis, Tsuga mertensiana, Abie lasiocarpa, Cassiope* spp., and *Phyllococe* spp. are the dominant plant above about 1,829 m. *Juniperus communis, Pinus monticola, Cassiop* spp., and *Phyllodoce* spp. are dominant plants in the higher Siskiyou Mountains. The Timberline Forest includes the *Tsuga mertensiana* Zone and the Alpine Zone of Franklin and Dyrness (1973).

Fig. 6. True Fir Forest near Lake of the Woods (Klamath County) at 1,524 m. The summit of Mount McLoughlin is in the background.

Fig. 7. Plants on the south side of Mount Ashland include *Abies magnifica shastensis*, *A. procera*, *Chamaecyparis nootkatensis*, and species of *Ceonothus* and *Arctostaphylos*.

GAZETTEER

Geographical localities to which references are made in the species accounts are listed below. Names are followed by distances from a certain reference point, usually Medford or Ashland. Most of the localities are located on 15-minute quadrangles (scale 1:62500) published by the U.S. Geological Survey. Quadrangles with publication dates covering Jackson County are: Tiller (1944), Abbott Butte (1944), Prospect (1956), Wimer (1954), Trail (1945), Butte Falls (1954), Rustler Peak (1955), Goldhill (1954), Medford (1954), Lake Creek (1954), Mount McLoughlin (1955), Ruch (1954), Talent (1954), Ashland (1954), and Hyatt Reservoir (1955). Spelling, nomenclature, and measurements conform to those appearing on the maps. Measurements in parentheses are from the metric scale. Numbers in brackets identify localities shown in Fig. 1.

Agate Desert. Open shrub area 4 miles (6.4 km) north of Medford and west of White City [17].

Agate Reservoir. A reservoir 8 miles (12.9 km) northeast of Medford; elevation, 1,500 feet (457 m) [22].

Anderson Creek. A tributary of Bear Creek beginning 7 miles (11.3 km) south-southwest of Phoenix at 4,189 feet (1,276.8 m) elevation [41].

Applegate River. Locality in species accounts refers to an area near Ruch [46].

Ashland. The southernmost city of Jackson County; elevation, 1,951 feet (594.6 m) [44].

Baldy or Mount Baldy. A rounded mountain 3 miles (4.8 km) northeast of Phoenix in the western Cascade Mountains; elevation, 3,844 feet (1,171.6 m) [34].

Bear Creek. Primary drainage of Bear Creek Valley (from near Ashland to the backwaters of Gold Ray Dam) [42].

Big Butte Creek. A major tributary of the Rogue River beginning in the Cascade Mountains at about 3,000 feet (914.4m) elevation and flowing into the Rogue River near 1,500 feet, 5 miles (8 km) east of Trail [5].

Central Point. A town 1 mile (1.6 km) northwest of Medford; elevation, 1,272 feet (387.7 m) [26].

Coleman Creek. A tributary of Bear Creek beginning 6 miles (9.6 km) north of Phoenix at about 5,185 feet (1,580.4 m) elevation near the foot of Anderson Butte, Siskiyou Mountains [38].

Eagle Point. A town north-northeast of Medford on Little Butte Creek; elevation, 1,365 feet (416 m) [9].

Fish Lake. A reservoir in the Cascade Mountains in extreme east-central Jackson County; elevation, 4,642 feet (1,414.9 m) [24].

Game Ponds. Area of diked ponds and marsh edge about 4 miles (6.4 km) north of Medford and 1 mile (1.6 km) south-southwest of White City; elevation, about 1,280 feet (390.1 m) [20]. This is the Ken Denman Game Management Area administered by the Oregon State Game Commission.

Gardner Reservoir. A reservoir in the Cascade Mountains near the headwaters of Yankee Creek about 10 miles (16.1 km) east of Medford; elevation, 2,760 feet (84.2 m) [23].

Goldhill. A town on the Rogue River about 8 miles (12.9 km) north-northwest of Medford; elevation, 1,085 feet (330.7 m) [16].

Gold Ray Dam. Power dam on the Rogue River about 6 miles (9.7 km) north-northwest of Medford; elevation, 1,168 feet (356 m) [12].

Hoover's Lakes. A series of five small reservoirs about 5 miles (8 km) northeast of Medford and 2 miles (3.2 km) southeast of White City; elevation, 1,326 feet (404.1 m) [19].

Howard Prairie Reservoir. Largest reservoir of Jackson County with an area of about 6 square miles (9.7 square km), in the Cascade Mountains about 14 miles (22.5 km) east of Ashland; elevation, 4,530 feet (1,380.7 m) [40].

Hyatt (Prairie) Reservoir. Cascade Mountain reservoir 11 miles east of Ashland; elevation, 5,016 feet (1,528.8 m) [45].

Jacksonville. A town 2 miles (3.2 km) west of Medford; elevation, 1,568 feet (477.9 m) [32].

Johns Peak. Three miles (4.8 km) northwest of Medford in the Klamath-Siskiyou Mountains; elevation, 2,807 feet (855.5 m) [28].

Kelly Slough. Backwater on the Rogue River formed by Gold Ray Dam.

Ken Denman Game Management Area. See Game Ponds.

Larson Creek. A tributary of Bear Creek beginning about ½ mile (0.8 km) north of Baldy at 3,400 feet (1,036.3 m) elevation. Records in the species accounts refer to the area along the Creek 3 miles (4.8 km) east of Medford at an elevation of about 1,800 feet (548.6 m) [31].

Little Butte Creek. A major tributary of the Rogue River beginning over 30 miles (48.3 km) east of its junction; elevation at its headwaters about 4,600 feet (1,402 m) [18].

Lower Rogue River Valley. Rogue River Valley downstream from Shady Cove to Jackson-Josephine County boundary.

Lower Table Rock. A mesa (about 101 hectares) adjacent to the Rogue River occupying Sam's Valley; elevation, 3,008 feet (916.8 m) [13].

Medford. Largest city in Jackson County located in the south-central portion of the county in Bear Creek Valley; elevation, 1,382 feet (421.2 m) [30].

Medford Municipal Airport. One and one-half miles (2.4 km) north of Medford; elevation, 1,318 feet (401.7 m) [25].

Mount Ashland. Highest point in the Siskiyou Mountains about 6 miles (9.7 km) south of Ashland; elevation, 7,533 feet (2,296 m) [49].

Mount McLoughlin. Highest point in the county located in the High Cascades in the extreme east-central part of the county; elevation, 9,495 feet (2,894.1 m) [15].

Old Military Bridge. Remains of a bridge once crossing the Rogue River at the mouth of Little Butte Creek; elevation about 1,200 feet (365.7 m) [14].

Oregon Switzerland. Forested area in the Cascade Mountains 3 miles (4.8 km) east of Medford and about 1 mile (1.6 km) southeast of Roxy Ann Peak; elevation about 2,600 feet (792.4 m) [29].

Phoenix. A town 3 miles (4.8 km) southeast of Medford in Bear Creek Valley; elevation, 1,543 feet (470.3 m) [36].

Pompadour Bluff. A rock scarp 2 miles (3.2 km) east of Phoenix in the Cascade foothills; elevation, 2,004 feet (610.8 m) [43].

Prospect. A town near the Rogue River in the Cascade Mountains; elevation, 2,598 feet (791.8 m) [2].

Rogue River. The major drainage of Jackson County, beginning in the extreme northern part of the county (its headwaters are at the northern boundary of Crater Lake National Park in Klamath County) and flowing southwest to about the west-central portion of the county. Its upstream elevation is about 3,400 feet (1,036.3 m); its downstream terminus, at the Jackson-Josephine County line, is about 1,000 feet (304.8 m) elevation [3].

Rogue River. A town 12 miles (19.3 m) northwest of Medford on the Rogue River, in the west-central part of the county; elevation, 1,001 feet (305.1 m) [11].

Roxy Ann Peak. A 3,571-foot (1,088.4 m) knob of the Cascade foothills 2 miles (3.2 km) northeast of Medford [27].

Ruch. A town near the Applegate River about 7 miles (11.3 km) southwest of Medford; elevation, 1,527 feet (465.4 m) [37].

Sam's Valley. A lowland area north of the Rogue River near Gold Ray Dam, divided by Lower and Upper Table Rocks; considered part of the Lower Rogue River Valley. Elevations range between about 1,200 (365.7) to 1,300 feet (396.2 m) [7].

Shady Cove. A town on the Rogue River about 17 miles (27.4 km) north of Medford; elevation, 1,399 feet (426.4 m) [6].

Talent. A town 5 miles (8 km) south of Medford in Bear Creek Valley; elevation, 1,635 feet (498.3 m) [39].

Tombstone. Rocks 1 mile (1.6 km) south of Baldy and abour 5 miles (8 km) north-north-west of Ashland; elevation, 3,227 feet (983.6 m) [35].

Trail. A town on the Rogue River 20 miles (32.2 km) north of Medford; elevation, 1,433 feet (436.7 m) [4].

Union Creek. A town in the Cascade Mountains near the Rogue River in northern Jackson County; elevation, 3,332 feet (1,015.6 m) [1].

Upper Rogue River Valley. Rogue River Valley upstream from Shady Cove to near Union Creek.

Upper Table Rock. A mesa adjacent to the Rogue River occupying Sam's Valley, with an area of about 500 acres (202.3 hectares); elevation, 2,068 feet (630.3 m) [8].

Voorhies Crossing. An area of Bear Creek named for its proximity to the railroad crossing at Voorhies, located about 1½ miles (2.4 km) south of Medford; elevation, 1,440 feet (438.9 m) [33].

Wagner Butte. A peak in the northern part of the Siskiyou Mountains 4 miles (6.4 km) southwest of Ashland; elevation, 7,140 feet (2,176.2 m) [48].

White City. A town 7 miles (11.3 km) north of Medford; elevation, 1,327 feet (404.4 m) [21].

Willow Creek Reservoir. A reservoir in the Cascade Mountains in east-central Jackson County; elevation, 3,014 feet (918.6 m) [10].

AVIAN COMMUNITIES

Of the 259 species of birds that have been recorded in Jackson County, 136 are represented by specimens and 14 species are documented by photographic records. There are 109 species included on the basis of reliable sight records. Four species formerly occurring in the county have been extirpated. Thus, I recognize a total of 255 species as definitely occurring in Jackson County.

Of this total 133 definitely breed in the county, 15 probably breed, and 13 species possibly breed. (See Plan of the Species Accounts for definitions of probably and possibly.) Thirty species are winter residents or regular winter visitors and 52 species are predominantly transient. Another 12 are considered accidentals or stragglers, mostly from east of the Cascade Mountains or from California. Three of the four extirpated species, Chukar,[1] Grey Partridge, and Bobwhite, were introduced and were unsuccessful in the county. The fourth species, Nuttall's Woodpecker, probably once bred in the Siskiyou Mountains of Jackson County.

Ten species have recently extended their breeding range into Jackson County or have increased in abundance as breeding species or as regular summer visitors.

Green Heron
Anna's Hummingbird
Allen's Hummingbird
Black Phoebe
Bank Swallow
Long-billed Marsh Wren
Blue-gray Gnatcatcher
Tricolored Blackbird
Yellow-headed Blackbird
Black-throated Sparrow

All of the 10 species definitely breed except the wren and blackbird that probably breed, and the two hummingbirds and the sparrow that are considered summer visitors.

Most of the Jackson County avifauna is similar to that of the Cascade Mountains and western valleys of Oregon. There are several subspecies restricted in Oregon to the geographic area covered in this paper (see Gabrielson and Jewett 1940). Lack of data at the subspecific level, however, precludes discussion of subspecies in this paper.

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[1] See Species Accounts for scientific names.

There are six *full* species in Oregon that are primarily restricted to Jackson County although they occur in certain parts of California, Nevada, and other States to the south and east. The Tricolored Blackbird breeds in eastern Oregon. The following species are known to breed in the Lower Rogue River Valley:

Acorn Woodpecker
Black Phoebe
Plain Titmouse
Blue-gray Gnatcatcher
Tricolored Blackbird
Brown Towhee

The Acorn Woodpecker, Plain Titmouse, and Brown Towhee were apparently well established as breeding species by the time Gabrielson and Jewett (1940) completed their field work in southern Oregon. The remaining three species have become breeding birds in the study area only recently.

Gabrielson and Jewett (1940:605) placed the Black Phoebe on their hypothetical list on the basis of two early records from the Umpqua Valley and from Salem. Breeding was confirmed in Jackson County in 1953 (Richardson and Sturges 1964). Grinnell and Miller (1944:253) do not list Siskiyou County, California, immediately to the south of Jackson County, as a breeding locality, although they cite breeding records from counties to the south and west of Siskiyou County as extreme northern breeding locations. It seems probable that the Black Phoebe first entered Jackson County via the Applegate River or Siskiyou Pass southeast of Ashland, both of which offer relatively low access over the Siskiyou Mountains.

Breeding was attempted by a pair of Blue-gray Gnatcatchers on Roxy Ann in 1963, and young were successfully fledged the following year (Richardson and Sturges 1964). At least one pair of this species has bred on Roxy Ann annually since then; six pairs and one nest were found in 1971. This species was reported breeding in Siskiyou County, California (at Hornbrook and Yreka), as early as 1870 (Grinnell and Miller 1944:368).

Tricolored Blackbirds have been known to breed in Klamath County, Oregon, since 1933 (Gabrielson and Jewett 1940). The species was first observed in Jackson County during the summer of 1956 and breeding was verified in 1960 (Richardson 1961).

Within Jackson County, certain breeding species are restricted to major plant communities.

Species restricted to the Chaparral-Oak Community, Lower Rogue Valley are the following:

California Quail
Ring-necked Pheasant
Virginia Rail
Sora
Poor-will
*Acorn Woodpecker
Western Kingbird
Black Phoebe
*Plain Titmouse
Wren-tit
Black-chinned Sparrow
Long-billed Marsh Wren
*Rock Wren
Blue-gray Gnatcatcher
Yellow-breasted Chat
Yellow-headed Blackbird
Tricolored Blackbird
*Northern Oriole
*Lazuli Bunting
Lesser Goldfinch
Brown Towhee
Lark Sparrow

The Sora and Black-chinned Sparrow possibly breed in the county, and the Long-billed Marsh Wren probably breeds there. All other pecies have been confirmed to breed in the county.

Five of the above species (designated *) also breed in the Chaparral-Oak Community of extreme southeastern Jackson County. This part of the county differs from the Lower Rogue River and Bear Creek valleys in climate, elevation, and somewhat by dominant vegetation. Average elevations are 610 m for the valley area and 914 m for the southeastern part of the county. Climatic conditions are not specifically known for the southeastern part of the county, but mean temperature is undoubtedly lower than in Medford and precipitation is probably greater with more snow. Dominant plants in the southeast include *Quercus* spp., *Pinus ponderosa*, and *Ceonothus* spp.

Species restricted to Mixed Conifer Forest (*Pinus* dominated) are: White-headed Woodpecker, Pygmy Nuthatch, and Green-tailed Towhee.

Species restricted to Mixed Conifer Forest (non-*Pinus*) are: Pygmy Owl, Vaux's Swift, Winter Wren, and MacGillivray's Warbler.

Species restricted to True Fir Forest are: Williamson's Sapsucker, Black-backed Three-toed Woodpecker, Olive-sided Flycatcher, Gray Jay, Hermit Warbler, and Cassin's Finch.

Species restricted to Timberline Forest are: Northern Three-toed Woodpecker and Clark's Nutcracker.

All avian species found in the Siskiyou Mountains are found in the Cascade Mountains. There are, however, seven species found in the Cascade Mountains that are not found in the Siskiyou Mountains. Gabrielson (1931:110) also mentioned similar differences. The differences in the avifauna between the Siskiyou and Cascade mountains are not readily apparent. Waring (1969) considers the Siskiyou Mountains to be poorly represented by mesophytes and Franklin and Dyrness

(1973) consider the dominant vegetation of the eastern Siskiyou and Cascade mountains to differ from that of the western Siskiyou Mountains. Information on the avifauna of the Siskiyou Mountains is not sufficient to compare species composition between the eastern and western Siskiyou Mountains. Further study in all disciplines of vertebrate zoology (S. Cross, personal communication), botany (J. F Franklin, personal communication), and geology (W. Purdom, personal communication) are required to evaluate the avian ecology in the Siskiyou Mountains.

The absence of seven species in the Siskiyou Mountains of Jackson County may be attributed to the absence of certain habitats. For example, no sizeable bodies of water exist in the drier Siskiyou Mountains which may account for the absence of Bank Swallows, Purple Martins, and Lincoln's Sparrows. Also, the Siskiyou Mountains have received little ornithological attention, and some species may have been simply overlooked. Listed below are seven species that breed in the Cascade Mountains with suggested reasons for the species absence in the Siskiyou Mountains.

Bank Swallow.—This swallow requires specific nesting habitat that is lacking in the Siskiyou Mountains.

Purple Martin.—This species is possibly not found in the Siskiyou Mountains because of little habitat near reservoirs where it has bred in the Cascade Mountains.

Black-billed Magpie.—Stragglers apparently originate from Klamath County moving over the Cascade Mountains.

Pygmy Nuthatch.—The distribution of this species is puzzling. *Pinus ponderosa* stands and Mixed Conifer Forest where *Pinus* is dominant cover much of the Siskiyou Mountains although there are no records of this nuthatch in Jackson County except from the Cascade Mountains. Discontinuous distribution of the species from California begins in the eastern Cascade Mountains.

Canon Wren.—Grinnell and Miller (1944:342) do not record this wren in the California Siskiyou Mountains, although it seems likely that it may breed in the canyons of the drier slopes of the eastern Siskiyou Mountains.

Red Crossbill.—There are so few records of this species in the county that its rarity is magnified by lack of man-hours spent in the Siskiyou Mountains; it is likely that the species has been overlooked.

Lincoln's Sparrow.—Lack of wet meadow-type habitat in the Siskiyou Mountains probably prevents this species from breeding there.

PLAN OF THE SPECIES ACCOUNTS

The sequence and names of genera and species follow the A.O.U. Check-list of North American Birds (1957) and the Thirty-second Supplement of the Check-list (American Ornithologists' Union 1973). Each species is introduced by its scientific name, followed by the common name. At the beginning of each species account I have listed recent specimens from Jackson County under the heading, "Specimen(s)." Specimens reported in recent literature are cited within the text of the species account. Photographs are cited under the heading of "Photograph(s)" to document the occurrence of certain species. Data listed under "Photograph(s)" and/or "Specimen(s)" include location, sex (specimens only), date, and if photographs exist, initials of the photographer. Important literature is cited and records outside Jackson County, especially from west of the Cascade Mountains in Oregon, are mentioned. References to Christmas Bird Counts (abbreviated CBCs) are made in some of the species accounts.

Terms indicating frequency of occurrence of species are often vague or misleading. In an effort to standardize terminology and reduce subjectivity, I have adopted the system developed by Arbib (1957:63–64).

In all instances of abundance I have chosen to use the nonbreeding abundance scale (Arbib 1957:63–64) due to the lack of sufficient quantitative data on breeding bird numbers; the abundance scale as used here thus refers to both breeding and nonbreeding species.

Abundance Scale

Abundant. Occurring in such numbers that a competent observer, in a single day, at the appropriate time and place (=habitat), might see or hear more than 500 individuals.

Very common. 101 to 500 individuals in a single day.

Common. 26 to 100 in a single day.

Fairly common. 6 to 25 in a single day.

Uncommon. One to five in a single day and no more than 25 per season.

Rare. One to five in a single day and no more than five per season.

Very Rare. No more than one per day and no more than one per season.

Frequency Scale

Regular. Recorded every year.

Irregular. Recorded less than once every year, but no less than once in 5 yr, on the average.

Occasional. Recorded less than once in 5 yr, but no less than once in 10 yr, on the average.

Sporadic. Recorded less than once in 10 yr, but no less than once in 20 yr, on the average.

Casual. Recorded less than once in 20 yr, on the average.

Accidental. Recorded, but because of the species normal range it is not expected to occur again. This term replaces the term "Exotic" proposed in Arbib (1957:63–64).

Seasonal Occurrence

Resident. Breeding species, summer resident, winter resident, or permanent resident.

Visitant (=*visitor*). A nonbreeding species which occurs either as a summer or a winter visitor.

I apply the term migrant to those species that occur only during migration. Records of migrants, and summer or winter residents are listed with dates of arrival and departure where possible.

Species that are considered definitely breeding are stated simply as breeding species or summer residents. Where the breeding status of certain species is in doubt I have used the terms "probably" or "possibly" breeds. The term "probably" refers to species that are regular summer residents and are often observed singing, but no nest, eggs, young, or food carrying by adults has been observed. "Possibly" breeds refers to summer residents that, although within their normal breeding range and habitat, have been observed infrequently and may breed in small numbers; no breeding behavior has been observed.

SPECIES ACCOUNT

Gavia immer. Common Loon.

The Common Loon is a rare and irregular visitor. There are sight records of single individuals from the game ponds, January 8, 1965, May 3, 1966, and November 15, 1965, and at Agate Reservoir, May 16, 1971. Three were observed at Willow Creek Reservoir on April 12, 1957.

Podiceps grisegena. Red-necked Grebe.

This grebe is an irregular migrant, occasionally breeding. It is uncommon on the Rogue River below Shady Cove and at Hoover's Lakes from late April to May and late August to November during migration. Three young with two adults were observed at Howard Prairie Reservoir on June 22, 1969, the only breeding record. Kebbe (1958b) records this grebe breeding on Upper Klamath Lake, Klamath County. An individual observed at Hoover's Lakes on January 12, 1959, is the only winter record.

Podiceps auritus. Horned Grebe.

Specimen: Prospect, sex not indicated, October 31, 1935. This species is a spring migrant occurring occasionally at Gardner Reservoir and the Game Ponds during April. One was observed north of Medford on January 10, 1960.

Podiceps nigricollis. Eared Grebe.

The Eared Grebe is an uncommon irregular migrant and winter resident on the Rogue River, Hoover's Lakes, and Lower Rogue River Valley ponds. Earliest, October 5, Hoover's Lakes; latest, April 25, north of Medford. Small numbers, usually single individuals, are observed north of Medford during winter.

Aechmophorus occidentalis. Western Grebe.

This large grebe is a regular uncommon spring and fall migrant and an irregular summer and winter visitor. One was observed at the Game Ponds on July 13, 1952. Single individuals are occasionally recorded on the Medford CBCs. Most frequently observed at the Game Ponds and Hoover's Lakes, this species may be expected at almost any Lower Rogue River Valley pond.

Podilymbus podiceps. Pied-billed Grebe.

Specimen: 3.2 km W Prospect, male, November 7, 1935. This small grebe has been found on many shallow ponds and reservoirs, Bear

Creek, and the Rogue River and may be expected throughout most of Jackson County. Although considered a fairly common resident, breeding has not been verified.

Pelecanus erythrorhynchos. White Pelican.

There are three records of this species in Jackson County. One was at the Game Ponds, August 16 through August 18, 1961, and one, possibly the same individual, was observed at Hoover's Lakes, August 18, 1961. Two were seen at the Game Ponds in October 1964. The species is considered a rare straggler in the area.

Phalacrocorax auritus. Double-crested Cormorant.

Specimen: Prospect, two males, April 8, 1935. The Double-crested Cormorant formerly nested at Hyatt Lake, but presently it is considered a rare irregular fall migrant. Individuals have been seen at Gold Ray and the Game Ponds in September.

Ardea herodias. Great Blue Heron.

This large heron is a common resident that may be found throughout the county near water. Solitary nesting pairs are most generally reported although eight occupied nests were observed at the Gold Ray-Kelly Slough February 20, 1963, and January 28, 1964.

Butorides virescens. Green Heron.

The Green Heron is an uncommon regular migrant and summer resident of the Chaparral-Oak Community of the Lower Rogue River Valley. Earliest, April 10, Phoenix; latest, late August, Medford. Breeding was not confirmed until 1970 when two young were fledged from an oak tree nest in residential Medford on August 24. A pair abandoned a nest containing two eggs at the same tree in 1971 after *Aphelocoma coerulescens* (Scrub Jays) reportedly ate the eggs. The pair renested nearby the same year, but success was not determined. Jewett (1945) first recorded this species breeding in northwestern Oregon and Evenden (1947) cites several breeding pairs near Corvallis.

Casmerodius albus. Common Egret.

This heron is an irregular visitor throughout the Lower Rogue River Valley. The species has been observed in January to March, June, July, October, and December. Single birds have been reported on 2 of 13 CBCs at Medford.

Egretta thula. Snowy Egret.

The Snowy Egret is known to have occurred in Jackson County twice in spring at Hoover's Lakes, April 25, 1960, and near Ashland, April 6, 1963.

Nycticorax nycticorax. Black-crowned Night Heron.

Specimen: 11.3 km SW Prospect, female, 1958. This heron is a common resident throughout the Lower Rogue River Valley in the

Chaparral-Oak Community. It breeds in small rookeries (10–20 nests), which change location north of Medford each year. Winter roosts of 5 to 10 birds have been found in Medford, Central Point, and Phoenix.

Ixobrychus exilis. Least Bittern.

Specimen: 8.0 km SW Prospect, sex ?, August 10, 1959. The only other record of this species in Jackson County is the sighting of an adult at Hoover's Lakes on July 29, 1961. Gabrielson and Jewett (1940) list it as a breeding species in neighboring Klamath County.

Botaurus lentiginosus. American Bittern.

Three recent records exist for this bittern. One individual was observed for 3 wk during September 1963, one was seen near Old Military Bridge on May 30, 1963, and one was at Hoover's Lakes on May 16, 1971. Gabrielson (1931) saw one at the headwaters of Big Butte Creek on September 20, 1927. Gabrielson and Jewett (1940) consider this species as an uncommon resident west of the Cascades, including Jackson County, but on the basis of available records it should be considered a rare migrant.

Olor columbianus. Whistling Swan.

This species is an uncommon to common regular migrant and winter resident on large ponds and reservoirs throughout the Lower Rogue River and Bear Creek valleys from November through March. It is regularly recorded on CBC's in numbers from 5 to 24 individuals.

Branta canadensis. Canada Goose.

Specimen: 12.9 km SW Prospect, male, October 30, 1958. Photograph: Hyatt Reservoir, pair with young, June 1964 (JH). This goose is a very common to uncommon migrant and winter resident that may be found on most waterbodies throughout the Lower Rogue River Valley. It nests at Howard Prairie and Hyatt reservoirs. The only summer record for the Lower Rogue River Valley is one observed at Hoover's Lakes on July 28, 1961.

Branta nigricans. Black Brant.

Photograph: Game Ponds, March 1963 (JH). The only record is of an adult photographed at the Game Ponds on March 14, 1963, following a snowstorm (Browning, 1966b). Gabrielson and Jewett (1940) have records of this straggler from the coast for Yamhill, Linn, Klamath, and Douglas counties. Kebbe (1958a) reports this species as occurring in the Klamath Basin but lists no specific records except for one bird shot in Warner Valley 64.4 km east of Lakeview in November 1950.

Anser albifrons. White-fronted Goose.

There are several sight records of this rare migrant and winter visitor in the Lower Rogue River Valley during January, April, May, October, and December.

Chen caerulescens. Snow Goose.

The Snow Goose is a rare winter visitor and spring migrant and records exist from various ponds north of Medford. One bird spent the winter of 1959–60 with a flock of domestic geese at Hoover's Lakes.

Anas platyrhynchos. Mallard.

Specimen: Ashland, female, May 14, 1971. This duck is a very common to common permanent resident increasing in number during winter and migration. It may be found throughout most of Jackson County.

Anas strepera. Gadwall.

The Gadwall is a fairly common regular winter resident and spring migrant throughout the southern portion of the county below 762 m. Earliest, November 22, Game Ponds; latest, March 13, Medford.

Anas acuta. Pintail.

The Pintail is a common migrant and winter resident at Hyatt, Howard Prairie, and Gardner reservoirs, Hoover's Lakes, Game Ponds, and at scattered small ponds throughout the Lower Rogue River Valley. This species has been recorded very regularly on the CBCs.

Anas crecca. Green-winged Teal.

This species is a common winter resident and migrant and uncommon summer resident that possibly breeds at the Game Ponds.

Anas discors. Blue-winged Teal.

Specimen: 12.9 km SW Prospect, male, June 20, 1945. This teal is an uncommon spring migrant and occasional summer resident of the Lower Rogue River Valley where shallow water and cattail cover are found. The earliest observation is April 22, Game Ponds, the latest, June 25, Hoover's Lakes. There are several "breeding" records of this teal from ponds north of Medford. As noted by McAllister (1949), these records may be of *Anas cyanoptera,* the Cinnamon Teal.

Anas cyanoptera. Cinnamon Teal.

The Cinnamon Teal is a fairly common migrant and rare winter visitor, most frequently seen on ponds north of Medford. It arrives in February and increases in numbers during March. Pairs have been seen as late as June on the Game Ponds and on Bear Creek near Phoenix.

Anas penelope. European Wigeon.

This species is a very rare straggler on the basis of three sight records of males. One was seen by two observers at Willow Springs Reservoir on March 3, 1958; and one each at Ashland on January 8, 1962, and on December 25, 1961, by several observers. Gabrielson and Jewett (1940) discuss several sight records and list five winter specimens from Oregon.

Anas americana. American Wigeon.

This duck is a common winter resident and irregular spring and summer visitor in the Lower Rogue River and Bear Creek valleys. This species has been recorded on 12 of 13 Medford CBCs with an average of about 30 birds per count.

Anas clypeata. Shoveler.

The Shoveler is a fairly common migrant and winter visitor. It arrives about November and leaves about March and may be expected throughout the county.

Aix sponsa. Wood Duck.

Specimens: 12.9 km SW Prospect, female, October 9, 1951; 17.7 km SW Prospect, male, date ?. The Wood Duck is a fairly common resident in the Lower Rogue River and Bear Creek valleys. Small numbers have also been observed on Gardner Reservoir. It breeds throughout its range; many breed on a small pond in Ashland's city park.

Aythya americana. Redhead.

The Redhead winters in small numbers and has been recorded from ponds north of Medford and Gardner Reservoir. This species may be expected on other bodies of water in Jackson County.

Aythya collaris. Ring-necked Duck.

Specimen: 3.2 km W Prospect, female, November 5, 1935. This duck is a common winter resident throughout Jackson County. Earliest, September, Rogue River Valley; latest, June 27, 1964, Hoover's Lakes.

Aythya valisineria. Canvasback.

The Canvasback is an uncommon winter resident recorded in the same areas as the Redhead, but in slightly greater numbers.

Aythya affinis. Lesser Scaup.

This diving duck is a common migrant and winter resident at Gardner Reservoir, ponds north of Medford, and Bear Creek Valley. This species is most frequently observed at Hoover's Lakes and the Game Ponds. It is regularly recorded on Medford CBCs; most birds arrive about September and depart by April.

Bucephala clangula. Common Goldeneye.

This duck is a rare winter resident and visitor and only three records are known from Jackson County. One bird wintered at the Game Ponds during 1961; one was observed at Willow Creek Reservoir on December 28, 1962, and two were seen on Howard Prairie Reservoir on January 14, 1962.

Bucephala islandica. Barrow's Goldeneye.

This goldeneye is a rare and irregular winter visitor. Twelve were seen at Hoover's Lakes during January and February 1966, and two females were there in 1969 (month ?). Gabrielson and Jewett (1940) report that it breeds regularly in Cascade Mountain lakes.

Bucephala albeola. Bufflehead.

Specimen: 3.2 km W Prospect, female, November 5, 1935. The Bufflehead is an uncommon and irregular winter resident. Gabrielson and Jewett (1940) give September 20 (Lake County) for their earliest Oregon date and May 15 (Tillamook County) for their latest date. Buffleheads have been recorded between those dates at Gardner Reservoir, Hoover's Lakes, and at the Game Ponds. They should also be expected at Willow Creek, Hyatt, and Howard Prairie reservoirs, and other mountain bodies of water.

Oxyura jamaicensis. Ruddy Duck.

Specimen: Ashland, male, April 23, 1960. The Ruddy Duck is a common winter resident from November to March, occurring wherever there is open water. During December at least one individual may be found on almost every body of water north of Medford as far as the Rogue River. Of 13 Medford CBCs, this species has been recorded on 10 at an average of 49 individuals per count.

Lophodytes cucullatus. Hooded Merganser.

This species is an uncommon late winter resident and spring migrant. Latest, April 5, Shady Cove. This merganser probably occurs throughout Jackson County. A record number of 20 was reported on the 1965 Medford CBCs.

Mergus merganser. Common Merganser.

Specimens: Three, 12.9 km SW Prospect, two females, May 27, 1935, one male, May 28, 1935. This duck is a common resident on the Rogue River below Prospect; it is less common on the Lower Rogue River Valley ponds in winter.

Mergus serrator. Red-breasted Merganser.

This merganser is a rare winter visitor. Two females and a male were observed on the Game Ponds on November 22, 1964, where one female and the male remained until mid-March 1965. Gabrielson and Jewett (1940) consider the species a casual inland winter visitor on the basis of late nineteenth century records.

Cathartes aura. Turkey Vulture.

Specimen: Ashland, male, April 15, 1959. The Turkey Vulture is a common summer resident throughout Jackson County, except in the Timberline Forest. Earliest, February 15, Medford; latest, September 30, Medford. It breeds in valley foothills and mountains.

Accipiter gentilis. Goshawk.

Specimens: Two, 12.9 km SW Prospect, male, December 18, 1944, and male, April 26, 1944; and two from Ashland, sex ?, February 2, 1963, and female, October 20, 1961. The Goshawk is a rare permanent resident probably throughout the forested areas of Jackson County, and it is an occasional visitor to the Chaparral-Oak Community during winter. There are several winter records of single individuals from Talent, Ashland, Medford, Larson Creek, and Shady Cove.

Accipiter striatus. Sharp-shinned Hawk.

Specimens: Five, both sexes, 12.9 km SW Prospect, March 24, 1949, October 25, 1958, November 11, 1958, January 22, 1937, and October 12, 1946; and one near Talent, sex?, June 10, 1969. Uncommon resident increasing in numbers in the Chaparral-Oak Community, especially along streams during winter. This species probably occurs throughout Jackson County in forested areas.

Accipiter cooperii. Cooper's Hawk.

Specimens: Three, 17.7 km SW Prospect, male, November 9, 1948, male, November 17, 1952, and female, March 6, 1937; Medford, female, March 25, 1971. This hawk is an uncommon resident that increases in numbers in the Chaparral-Oak Community, especially along streams, in winter. The species is slightly more common, or at least more conspicuous, than the Sharp-shinned Hawk during winter. The Cooper's Hawk has been observed at Roxy Ann Peak, Pompadour Bluffs, Upper Table Rock, Larson Creek, Coleman Creek, Tombstone, and in the Cascades along Dead Indian Road.

Buteo jamaicensis. Red-tailed Hawk.

Specimens: Ashland, female, October 30, 1961; Medford, male, no date. This soaring hawk is a common permanent resident occurring at most elevations throughout Jackson County. It is less common in Lower Rogue River and Bear Creek valleys during summer.

Buteo swainsoni. Swainson's Hawk.

The Swainson's Hawk is a rare straggler west of the Cascades. Three authentic sight records have been made by competent observers: One at Medford, September 8, 1958; one observed twice in the foothills east of Ashland during August 1963; and one between Howard Prairie and Hyatt reservoirs, May 11, 1961. This *Buteo* has been reported three times within recent years on Medford CBCs. Although these winter records have been published (*Aud. Field Notes* 1965:320), none of the observers reporting these birds were familiar with the species. Until more reliable data can be collected on winter occurrences, Swainson's Hawk should be considered only as a rare migrant and summer visitor.

Buteo lagopus. Rough-legged Hawk.

This species is a rare winter straggler. One was observed at Medford on November 24, 1958; two were seen north of Medford on December 30, 1960; and one wintered, 1960-61, at White City.

Single birds have been recorded in the Lower Rogue River Valley during the winter of 1969, 1970, and 1971. An individual was shot near Medford, February 22, 1930 (Gabrielson 1931).

Buteo regalis. Ferruginous Hawk.

This hawk is a rare straggler occurring on Mount Ashland, Anderson Creek (457 m), and north of Medford near White City, on September 1, 1954, September 20, 1958, and December 27, 1957, respectively. One individual was observed on each occasion.

Aquila chrysaetos. Golden Eagle.

Specimen: Ashland, female, November 3, 1970. Probably a permanent resident. There are records of this eagle from Ashland, Baldy, Upper Table Rock, Johns Peak, Roxy Ann Peak, Pompadour Bluffs, and various locations in the Lower Rogue River and Bear Creek valleys for the months of March, August, November, and December. Gabrielson and Jewett (1940) mention one sight record from Goldhill.

Haliacetus leucocephalus. Bald Eagle.

Photograph: Sterling Creek (near Jacksonville), adult, February 1964 (JH). The Bald Eagle is probably a permanent resident in the High Cascades and Siskiyou mountains. A pair was periodically observed at a nest near Hyatt Lake during the spring of 1970, but the actual breeding status of this pair is unknown. This species has been seen several times at Gardner, Hyatt, Howard Prairie, and Willow Creek reservoirs during summer and winter months. There are several records from along the Rogue River and Larson Creek.

Circus cyaneus. Marsh Hawk.

The Marsh Hawk is an uncommon permanent resident throughout the Lower Rogue River and Bear Creek valleys. This hawk is often observed north of Medford to White City. An average of three individuals are reported annually on the CBCs.

Pandion haliaetus. Osprey.

The Osprey is an uncommon permanent resident in the Lower Rogue River Valley. Gabrielson and Jewett (1940) stated that several pairs were nesting along the Rogue River, but populations have been diminishing throughout its Oregon range. Until recently the only known nest in Jackson County was near Shady Cove on the Rogue River, which was occupied annually from 1948 to 1964. Nesting at this site was not observed again until 1970 and 1971. Nesting pairs were observed near Gold Ray Dam and at Hyatt Reservoir in 1970 and 1971. One individual was recorded from Little Butte Creek near Eagle Point on November 22, 1964.

Falco mexicanus. Prairie Falcon.

This species is an uncommon irregular visitor. The Prairie Falcon has been reported at Roxy Ann Peak, Ashland, Phoenix, and White

City in December to May. Stevenson and Fitch (1933) report a sight record of an individual 9.7 km south of Medford.

Falco peregrinus. Peregrine Falcon.

The Peregrine Falcon is a rare migrant along the Lower Rogue River. There are two records from Medford, January 7, and February 15, 1958.

Falco columbarius. Pigeon Hawk.

Specimen: Two males, 12.9 km SW Prospect, December 7, 1947, and October 30, 1950. This falcon is a rare winter visitor. Thomas McCamant (unpublished notes) stated that he saw one or two per year at various locations during 10 yr of observations in Jackson County. Gabrielson and Jewett (1940) mention that there have been sight records in the county and consider the species to be a rare straggler west of the Cascade Mountains.

Falco sparverius. Sparrow Hawk.

Specimens: 17.7 km SW Prospect, male, December 27, 1952; Medford, male, June 1, 1962. The Sparrow Hawk is a very common permanent resident throughout the lower elevations of the county in the Chaparral-Oak Community.

Dendragapus obscurus. Blue Grouse.

This species is a fairly common resident in the Cascade and Siskiyou mountains in the Mixed Conifer and True Fir forests.

Bonasa umbellus. Ruffed Grouse.

Specimens: 12.9 km SW Prospect, male, January 21, 1959; 14.5 km SW Prospect, female, May 12, 1959. The Ruffed Grouse is a fairly common permanent resident in the Mixed Conifer Forest in the mountains of Jackson County; it occurs at lower elevations (valley foothills) during winter.

Colinus virginianus. Bobwhite.

The only recent record is of a male in May 1957 at the Game Ponds. Gabrielson (1931) reported a lone male observed near Brownsboro (about 12.9 km east of Eagle Point), August 23, 1923. This species was introduced many years ago (probably early 1900), but has been unsuccessful in this area (Gabrielson and Jewett, 1940).

Lophortyx californicus. California Quail.

Specimens: 6.4 km N Eagle Point, two males and one female, October 30, 1955; Ashland, male, May 9, 1971. This quail is a common to uncommon permanent resident in the Chaparral-Oak Community of the Lower Rogue River and Bear Creek valleys and foothills. The species breeds throughout its range. The latest nesting date is of a female hatching eight eggs on September 1, 1960, at Phoenix.

Oreortyx pictus. Mountain Quail.

Specimen: Howard Prairie, female ?, fall 1960. The Mountain Quail probably occurs throughout the Mixed Conifer Forest of the county with the greatest number found at 610 to 1,372 m. The species has been seen many times on the slopes of Baldy and near the summit of Roxy Ann Peak. Gabrielson and Jewett (1940) considered it to be fairly common in the foothills around the Lower Rogue River Valley and cite egg records from Brownsboro (about 12.9 km east of Eagle Point).

Phasianus colchicus. Ring-necked Pheasant.

Specimens: Several from Lower Rogue River Valley of both sexes and all months. Introduced. This pheasant is a common permanent resident throughout the Lower Rogue River and Bear Creek valleys up to about 610 m. It is most often found in agricultural lands, particularly in fields but also in orchards.

Alectoris chukar. Chukar.

Introduced. About 2,000 were introduced by the Oregon State Game Commission to various areas of Jackson County after August 21, 1957. Releases were also made in March and September 1958 and July 1959. Fifty (each) were released at Pinehurst, White City, and Pilot Rock (on eastern Siskiyou Mountains) on July 20, 1962. Sight records of this species were periodically made shortly after the release periods but since the last release in 1962 none have been reported.

Perdix perdix. Gray Partridge.

Introduced. About 1,500 were introduced to the county by the Oregon State Game Commission after 1960. The birds were released in March and August of 1960, and in March 1961–62. Birds were periodically sighted shortly after the release periods, especially east of Ashland near Pompadour Bluffs. The latest record was made in 1964.

Grus canadensis. Sandhill Crane.

The Sandhill Crane is a fairly regular migrant. Earliest, April 5, Game Ponds; latest, October 4, Talent. Two cranes were seen during August 1963 at Howard Prairie Reservoir and one observed on November 10, 1963, at Hoover's Lakes. Migrants west of the Cascades have also been reported from such areas as Portland (*Aud. Field Notes* 1961:433), Corvallis (*Aud. Field Notes* 1965:506), Eugene (Gullion 1948, 1951), and Diamond Lake in Douglas County (Thatcher 1947). Gullion (1947) reports this species breeding in western Deschutes County and suggests that it breeds at lakes and reservoirs of the Cascade Mountains.

Rallus limicola. Virginia Rail.

Specimen: Ashland, male, December 8, 1967; 8.1 km E Jacksonville, male, November 20, 1971. This rail is an uncommon resident in the Medford-Phoenix-White City area. The first recent record of the Virginia Rail was of an immature at Voorhies Crossing on July 23, 1961. This area was flooded by Bear Creek during the winter of 1962. The existing cattail marsh was heavily silted and willows took over the following spring. Since then most of the reports have been from the Game Ponds and a marsh just east of Medford where single nests were found in 1970 and 1971. The Virginia Rail probably breeds sparingly in isolated marshes north and east of Medford.

Porzana carolina. Sora.

Specimen: Medford, male, April 28, 1972. The Sora is a rare permanent resident and possible breeder at the Game Ponds. The first Jackson County record of the Sora was of a bird killed striking a window in Medford on May 20, 1964. The late Walt Cavanough (personal communication) of the Oregon State Game Commission stated that he had seen Soras during several summers in the edges of the Game Ponds where cattails were abundant. There are also winter records from the Game Ponds, January 1, 1965, and February 18, 1965; it has been reported less frequently from scattered cattail marshes from Medford north to the Rogue River and east to near the base of Roxy Ann Peak.

Fulica americana. American Coot.

The coot is a common to very common migrant and winter resident; it is fairly common as a breeding species. The coot may be found on almost any body of water during migration and during the winter in the Lower Rogue River and Bear Creek valleys. The species breeds most commonly at the Game Ponds and at Hoover's Lakes.

Charadrius vociferus. Killdeer.

Specimen: 3.2 km S Medford, sex?, May 27, 1969. The Killdeer is a very common and widely distributed species throughout the county on residential lawns, fields, and stream and lake shores. It breeds throughout its range. Downy young have been observed as early as April 6.

Pluvialis squatarola. Black-bellied Plover.

This plover is very rare. One individual was observed on a lagoon on the Rogue River near Shady Cove by three observers on April 2, 1960. Gabrielson and Jewett (1940) consider this species an uncommon migrant and winter resident along the Oregon coast. Gullion (1951) considers the Black-bellied Plover to be a common fall migrant in the southern Willamette Valley, Oregon, reporting a record of 91 birds in mid-October. Marshall (1959) reports records for October and September, and one spring record on May 14, 1958, at Harney Lake (Harney County).

Capella gallinago. Common Snipe.

Specimens: Two, 12.9 km SW Prospect, sex ?, September 26, 1947, and male, December 6, 1948. This species is a fairly common summer resident and breeding species and an uncommon winter resident. The Common Snipe is found throughout the lower Jackson County, probably not above Prospect (792 m), and is usually reported on the Medford CBCs, averaging about nine birds per count.

Numenius americanus. Long-billed Curlew.

The Long-billed Curlew is very rare; one was recorded at Hoover's Lakes April 8, 1961. Gabrielson and Jewett (1940) consider this curlew to be casual west of the Cascades on the basis of specimens from Linn and Lincoln counties.

Actitis macularia. Spotted Sandpiper.

This sandpiper is a common to fairly common resident, found along almost any stream in Jackson County up to about 1,372 m. The Spotted Sandpiper is an uncommon winter resident in the Lower Rogue River and Bear Creek valleys.

Tringa solitaria. Solitary Sandpiper.

This species is a rare visitor. One Solitary was sighted near Gold Ray Dam on September 11, 1966, and four were observed at Shady Cove on August 29, 1961 (Browning, 1966b). Gabrielson and Jewett (1940) consider it a straggler to western Oregon and cite a specimen taken at Portland on May 5, 1930. Evenden et al. (1950) consider this species a rare spring migrant in the Willamette Valley, and Gullion (1951) reports both spring and fall records.

Tringa melanoleucus. Greater Yellowlegs.

The Greater Yellowlegs is a fairly common migrant and rare winter visitor. Latest, 5 October, Phoenix. It has been reported once at Hyatt Reservoir and once at Howard Prairie Reservoir. Several sight records are from Hoover's Lakes. This species has been reported in winter only once, December 30, at Hoover's Lakes (Medford CBCs).

Tringa flavipes. Lesser Yellowlegs.

This species is an uncommon visitor that has occurred at Hoover's Lakes in April, July, and September and twice near Shady Cove in July. Earliest, April 15, Hoover's Lakes; latest, September, Hoover's Lakes.

Catoptrophorus semipalmatus. Willet.

Photograph: Hoover's Lakes, May 21, 1962 (JH). The Willet is a rare spring visitor. Three Willets were seen at Hoover's Lakes on April 20, 1965, two on April 28, 1958, and one on May 21, 1962. One was reported near Shady Cove on April 10, 1962.

Calidris melanotos. Pectoral Sandpiper.

Photograph: Hoover's Lakes, April 9, 1964 (JH). This sandpiper is known only from the photographic record (Browning 1966b). Gabrielson and Jewett (1940) list two fall records of the Pectoral Sandpiper from Multnomah and Lincoln counties and Gullion (1951) considers this species as a *common* (italics mine) fall migrant in the southern Willamette Valley.

Calidris bairdii. Baird's Sandpiper.

This peep sandpiper is a very rare visitor in spring, known only from two sight records: April 10, 1964, and May 5, 1965, at Hoover's Lakes. Both records were made by experienced observers, and during each observation *Calidris mauri* (Western Sandpiper) and *C. minutilla* (Least Sandpiper) were present for comparison. Gabrielson and Jewett (1940) cite several specimens from the coast taken during the fall and a flock seen (one specimen collected) in Wallowa County. Gullion (1951) considers Baird's Sandpiper to be a common fall migrant in the southern Willamette Valley.

Calidris minutilla. Least Sandpiper.

This small sandpiper is a fairly common spring migrant and less common fall migrant in the White City area. Earliest spring, February 27, Hoover's Lakes; latest spring, late May. Earliest fall, July 14, Howard Prairie Reservoir; latest fall, September 24, Phoenix. Six individuals were sighted on the Medford CBCs at Hoover's Lakes on December 30, 1960.

Calidris alpina. Dunlin.

The Dunlin is a fairly common spring migrant in the White City area. Earliest, April 8, Hoover's Lakes; latest, June 10, Hoover's Lakes. Six were recorded on a Medford CBC on December 28, 1962.

Calidris pusilla. Semipalmated Sandpiper.

This sandpiper is a very rare visitor. One bird identified as the Semipalmated Sandpiper was seen at Hoover's Lakes on April 14, 1964. There are no known specimens of this species in Oregon and it should remain on the Oregon hypothetical list (Gabrielson and Jewett 1940:604).

Calidris mauri. Western Sandpiper.

The Western Sandpiper is an uncommon spring and fall migrant in Bear Creek Valley and the White City area. Earliest spring, April 5, Game Ponds; latest spring, early May, Hoover's Lakes; earliest fall, July 13, Hoover's Lakes; latest fall, November 28, Phoenix.

Limnodromus spp. Dowitcher.

Both *Limnodromus griseus* and *L. scolopaceus* probably occur in Jackson County, but available records do not provide adequate evidence for species documentation. Dowitchers are fairly common migrants with records from Lower Bear Valley (Phoenix to Gold Ray Dam area) and the White City area. Earliest spring, March 31, Medford; latest spring, May 6, Medford. The only fall record is of four birds on July 14 at Howard Prairie Reservoir. One Dowitcher was seen on Bear Creek near Phoenix on January 2, 1959.

Recurvirostra americana. American Avocet.

The avocet is a very rare visitor reported three times at Hoover's Lakes: summer 1960, May 20, 1963, and September 18, 1964. Gabrielson and Jewett (1940) cite two specimens taken near Corvallis (Benton County) on July 29, 1900.

Himantopus mexicanus. Black-necked Stilt.

The Black-necked Stilt is a very rare visitor. The only record of this species is of one at Hoover's Lakes on April 25, 1960, observed by two experienced observers.

Phalaropus fulicarius. Red Phalarope.

The Red Phalarope is a rare visitor occurring south of Shady Cove on the Rogue River where a pair were observed on November 13, 1960 (Browning 1966a). Alderson (1961) reports several inland records from northwestern Oregon for November and October.

Steganopus tricolor. Wilson's Phalarope.

Photograph: Hoover's Lakes, May 1962 (JH). This phalarope is an uncommon migrant that formerly bred at Hoover's Lakes until 1969. Earliest, April 20, Hoover's Lakes; latest, August 7, Hyatt Reservoir. Gabrielson and Jewett (1940) consider the Wilson's Phalarope to be a rare straggler west of the Cascades and give April 21 (Malheur County) for their earliest date and September 22 (Harney County) for their latest date. These authors do not consider this species to breed west of the Cascades.

Lobipes lobatus. Northern Phalarope.

Photographs: Ashland May 21, 1965 (JH); Hoover's Lakes, June 1965 (JH); Sam's Valley, August 24, 1963 (DT). This phalarope is a rare migrant and has been seen at most bodies of water of the Chaparral-Oak Community. Gabrielson (1931) collected a specimen of Northern Phalarope from a flock of three at Savage Rapids (on the Rogue River, Josephine County) on May 17, 1922. The species is considered a very common migrant in the Willamette Valley (Gullion 1951).

Larus occidentalis. Western Gull.

Six Western Gulls were at the Game Ponds on May 30, 1961. Gabrielson and Jewett (1940) list inland records for Portland, The Dalles, and Corvallis of birds observed during winter.

Larus californicus. California Gull.

Specimen: 12.9 km N Medford, female, August 6, 1958. Photograph: Hoover's Lakes, first year immature, March 27, 1962 (JH). These are the only county records of this species that breeds to the east in Klamath County.

Larus delawarensis. Ring-billed Gull.

Specimen: Medford, sex ?, September 21, 1965. This gull is a regular uncommon spring visitor and irregular rare winter visitor in the Lower Rogue River and Bear Creek valleys. Earliest, February 24, Emigrant Reservoir; latest, May 17, Hoover's Lakes. The Ring-bill has been recorded twice on Medford CBCs, one on December 28, 1953, and two on December 30, 1965.

Larus pipixcan. Franklin's Gull.

The Franklin's Gull is a very rare visitor. An immature was sighted repeatedly by several observers north of Medford from April 25 to July 28, 1961, at both Hoover's Lakes and the Game Ponds (Browning 1966b). Jewett (1949) reported the Franklin's Gull breeding at Malheur National Wildlife Refuge in Harney County.

Larus philadelphia. Bonaparte's Gull.

Photograph: Hoover's Lakes, breeding plumage, May 20, 1962 (JH). The Bonaparte's Gull is an irregular and uncommon spring and fall migrant likely to occur in the Lower Rogue River and Bear Creek valleys in May and November. It is most frequently reported from the White City area.

Sterna forsteri. Forster's Tern.

The Forster's Tern is a very rare spring migrant; only two records exist during recent years at Hoover's Lakes and at the Game Ponds on May 30, 1960, and ? May 1961, respectively.

Hydroprogne caspia. Caspian Tern.

This large tern is a rare irregular fall visitor. The species was first reported in Jackson County at Fish Lake where two adults were seen on July 19, 1961 (*Aud. Field Notes* 1961:488). Three others were observed at Emigrant Reservoir in fall 1969 and 1970, and one at Agate Reservoir in fall 1970.

Chlidonias niger. Black Tern.

This dark tern is an uncommon spring and summer visitor on ponds in the White City area. Earliest, mid-May. This species formerly bred at Hoover's Lakes and the Game Ponds.

Synthliboramphus antiquum. Ancient Murrelet.

Specimen: Medford, male, winter plumage, March 3, 1966. Accidental. The Ancient Murrelet is known only from the above record (Browning 1972). Jewett (1951) cites a specimen of the species taken at Bend (Deschutes County) on November 18, 1950.

Columba fasciata. Band-tailed Pigeon.

Specimens: Two females, 12.9 km SW Prospect, September 15, 1948. The Band-tailed Pigeon is a fairly common migrant in the Mixed Conifer Forest area. The species probably breeds in the county. Band-tailed Pigeons have been reported twice in winter.

Zenaida macroura. Mourning Dove.

Specimens: 12.9 km SW Prospect, sex ?, September 11, 1959; Medford, male, June 14, 1970. The Mourning Dove is an abundant permanent resident and breeding species throughout Jackson County in the Chaparral-Oak Community.

Tyto alba. Barn Owl.

Specimens: Several from various localities and dates. The Barn Owl is an uncommon permanent resident. The species has been reported only from the Rogue River Valley below Prospect and from Bear Creek Valley, although it probably occurs and breeds elsewhere in the county.

Otus asio. Screech Owl.

Specimens: 17.7 km NW Prospect, male, May 10, 1959; 12.9 km SW Prospect, female, January 17, 1952. This owl is a fairly common permanent resident in the Chaparral-Oak Community and Mixed Conifer Forest, but more common in the former in the valley foothills. Gabrielson and Jewett (1940) list a Screech Owl taken at Eagle Point on March 21, 1925.

Bubo virginianus. Great Horned Owl.

Specimen: 12.9 km SW Prospect, male, May 3, 1935. This large owl is a common permanent resident occurring throughout most of Jackson County, especially in the margins of the Chaparral-Oak Community and Mixed Conifer Forest.

Glaucidium gnoma. Pygmy Owl.

Specimens: Three, 12.9 km SW Prospect, female, November 11, 1959; male, November 14, 1951; male, December 7, 1947. This small owl is an uncommon permanent resident in the Mixed Conifer Forest and Chaparral-Oak Community. The Pygmy Owl has been seen in various localities in the Lower Rogue River and Bear Creek valleys as well as on Roxy Ann Peak, and at Oregon Switzerland, Gardner Reservoir, Prospect, and Shady Cove.

Speotyto cunicularia. Burrowing Owl.

Photographs: Several, different months, E Medford (DT); Hoover's Lakes, May 11, 1963 (JH); White City, January 12, 1963 (JH). The Burrowing Owl formerly bred throughout the county in openings of the Chaparral-Oak Community in the Lower Rogue River Valley. The species was a common breeding species in the Medford-White City area during the 1920's and 1930's (Carl Richardson, personal ommunication). Presently, this owl is considered a rare visitor in he White City-Agate Reservoir area.

Strix nebulosa. Great Gray Owl.

This large owl is uncommon in Jackson County. Jewett (*in* Gabriel-on, 1931) saw a 7-yr-old specimen in a Medford store on December 14, 918, and was told by a taxidermist that he had mounted three Great Gray Owls from near Prospect in the winter of 1917. Stevenson nd Fitch (1933) saw one 11.3 km east of Ashland on December 16, 932, and one south of Medford during the last week of December 929. One Great Gray Owl was seen near the town of Rogue River on Foots Creek on January 26, 1959 (Alderson 1960). This species s a fairly common breeding bird at Fort Klamath (Klamath County).

Asio otus. Long-eared Owl.

The Long-eared Owl is a very rare winter visitor known only from a single sight record in eastern Medford on December 29, 1964, during an unusual cold period and heavy snow. Gabrielson and Jewett (1940) report this owl as wintering sparingly in western Oregon.

Asio flammeus. Short-eared Owl.

The Short-eared Owl is an uncommon winter visitor in the Medford-White City area, most often observed at Hoover's Lakes. The largest concentration of this species was nine at Hoover's Lakes on January 2, 1965 (*Aud. Field Notes* 1965:411). Gabrielson (1931) cites one Short-eared Owl seen by Jewett "near Medford," December 19, 1918.

Aegolius acadicus. Saw-whet Owl.

Specimen: Prospect, male, January 24, 1951. This owl is an uncommon permanent resident that probably occurs wherever there is conifer forest. Specimens are cited from Jackson County by Gabrielson and Jewett (1940).

Phalaenoptilus nuttallii. Poor-will.

Specimen: Prospect, female, August 5, 1960. The Poor-will is an uncommon summer resident in the Chaparral-Oak Community, especially at Roxy Ann Peak. Adults were reported feeding young on Roxy Ann (at 762 m) on July 20, 1971. The species is occasionally observed north of Medford and White City. Gabrielson and Jewett (1940) took a specimen on June 21, 1929, at Brownsboro (about 12.9 km E Eagle Point) and consider this species a regular summer resident in the eastern part of Jackson County and "probably other parts of the Rogue River Valley."

Chordeiles minor. Common Nighthawk.

Specimen: 12.9 km SW Prospect, male, August 15, 1952. This common summer resident probably breeds throughout the Chaparral-Oak Community. Earliest, May 23, White City; latest, September 10, 1960.

Chaetura vauxi. Vaux's Swift.

The Vaux's Swift is a common summer resident in Mixed Conifer and True Fir forests. Migrant swifts occur in the Chaparral-Oak Community. Earliest, April 30, Medford; latest, September.

Archilochus alexandri. Black-chinned Hummingbird.

This hummingbird is an uncommon regular summer visitor, reported only from near Shady Cove since 1968. Earliest, March 26; latest August 15. Several pairs of Black-chinned Hummingbirds were reported in June 1970 and a young male was sighted July 25, 1970 (*Aud. Field Notes* 1970:710). Gabrielson and Jewett (1940) list three specimens taken in Oregon during June (1915, 1919, and 1925).

Calypte anna. Anna's Hummingbird.

Specimen: Central Point, sex ?, March 19, 1972. The Anna's Hummingbird is an irregular and rare winter visitor and a regular uncommon summer visitor in the Lower Rogue River and Bear Creek valleys. A male at Ashland on December 21, 1958 (*Aud. Field Notes* 1960:335) was the first Jackson County record. This species has been observed at the Star Ranger Station on the Applegate River in Mixed Conifer Forest during the spring and summer. The latest summer record is July 7, near Shady Cove in Chaparral-Oak. A male was collected at Brookings (Curry County) on March 21, 1966 (Browning and English 1967a). Zimmerman (1973) reviews recent distributional records of the species.

Selasphorus platycercus. Broad-tailed Hummingbird.

This hummingbird is a rare summer visitor reported only at a bird feeder near Shady Cove. Both males and females have been observed since 1968 during May and a young bird was reported on July 25, 1970. Although female Rufous, Allen's, and Calliope hummingbirds were present for comparison, I feel that the records of females and young are questionable. No recent records of the Broad-tailed Hummingbird exist elsewhere in Oregon. Gabrielson and Jewett (1940) consider it to be a rare summer visitor to extreme eastern Oregon.

Selasphorus rufus. Rufous Hummingbird.

Specimen: Medford, sex ?, April 19, 1965. This species is a common summer resident, breeding throughout most of the county. Earliest, February 23, Gold Ray Dam; latest, October 25, Medford. Most individuals leave by the end of September.

Selasphorus sasin. Allen's Hummingbird.

A rare irregular summer visitor, Allen's Hummingbirds have been observed at Medford in April, at Shady Cove in May and July, at Talent in June, and at Phoenix in July and August. Earliest, April 1; latest, August 12. One was seen north of Brookings on April 12, 1969

Aud. Field Notes 1969:617) and one was observed at Crater Lake National Park (Klamath County) on July 6, 1964 (Browning 1966a).

Stellula calliope. Calliope Hummingbird.

Specimen: Ashland, sex ?, May 12, 1965. This small hummingbird is a common to fairly common valley migrant, and a fairly common breeding bird in the Cascade and Siskiyou mountains. Earliest, April 30, Ashland; latest, late September, Jackson County.

Megaceryle alcyon. Belted Kingfisher.

Specimens: Two males, 12.9 km SW Prospect, March 28, 1961, and December 16, 1959. The Belted Kingfisher is a fairly common permanent resident in the Chaparral-Oak Community and higher elevations along the major tributaries of the Rogue River.

Colaptes auratus (*auratus* group) Common Flicker.

This group includes birds with yellow wing shafts. Specimen: 4.8 km SE Ashland, female, December 23, 1967. Birds of the *auratus* group are very rare; only one sight record, 3.2 km north of Talent during February 1962 (Browning 1966a), in addition to the specimen cited. Giles (1958) observed one on May 1, 1957, at Lower Klamath National Wildlife Refuge, Siskiyou County, California. Identifiable remains of a yellow-shafted bird were found on March 22, 1966, near Brookings, Curry County (Browning and English 1967b).

Colaptes auratus (*cafer* group) Common Flicker.

This group includes birds with red wing shafts. Specimens: Two females, 12.9 km SW Prospect, January 29, 1947, and April 8, 1946; 9.7 km N Prospect, male, April 18, 1935. Birds of the *cafer* group are common permanent residents throughout the county below the coniferous forests and may also be found at higher elevations during summer months where deciduous growth occurs.

Hybrids between the *cafer* and *auratus* groups have occurred rarely in Jackson County. Specimen: 9.7 km N Prospect, male, April 18, 1935. Photograph: Talent, November 6, 1961 (DT). Browning (1966a) reports records from Talent on November 6, 1961, from Medford on February 1, 1964, and two records at Phoenix on December 14 to 22, 1964, and October 11, 1965.

Dryocopus pileatus. Pileated Woodpecker.

Specimens: Two, 12.9 km SW Prospect, female, February 21, 1946; male, January 17, 1946. This large woodpecker is an uncommon permanent resident in the Mixed Conifer Forest and is rare at lower elevations.

Melanerpes formicivorus. Acorn Woodpecker.

Specimens: Male and female, 17.7 km SW Prospect, April 20, 1949; NW Medford, female, May 9, 1971; 8.0 km W Butte Falls, male, May 14, 1971. The Acorn Woodpecker is a fairly common permanent resident in the Chaparral-Oak Community, especially the Lower Rogue River and Bear Creek valleys.

Asyndesmus lewis. Lewis' Woodpecker.

Specimens: Eight specimens from areas southwest of Prospect, collected during September of different years; 20.9 km N Medford, male, May 5, 1961. The Lewis' Woodpecker is a fairly common summer resident of the Chaparral-Oak Community and lower elevations of the Mixed Conifer Forest. The species is a common winter resident, the numbers varying from year to year during this season. It has been recorded on 10 of 13 Medford CBCs averaging 27 individuals per count; 145 were recorded on the December 30, 1965, count.

Sphyrapicus varius. Yellow-bellied Sapsucker.

Specimens: Eight specimens from 12.9 km SW Prospect, taken in various months and years. This sapsucker is a fairly common permanent resident throughout Jackson County.

Sphyrapicus thyroideus. Williamson's Sapsucker.

Rare. This sapsucker is known in Jackson County from two sight records and a specimen cited by Gabrielson and Jewett (1940) taken in the Siskiyou Mountains south of Ashland. An individual was observed near Howard Prairie Reservoir on September 8, 1958, and one was seen in the Siskiyou Mountains near the town of Siskiyou on May 30, 1960. Gabrielson and Jewett (1940) consider this species to be a summer resident of the summit and eastern slope of the Cascade Mountains. It may breed in the pine forests of the Cascade and Siskiyou mountains.

Dendrocopos villosus. Hairy Woodpecker.

Specimens: Seven specimens from the Prospect area from different months and years. The Hairy Woodpecker is an uncommon to fairly common permanent resident throughout most of the county. Gabrielson and Jewett (1940) give summer records from Butte Falls, Rustler Peak (1,892 km), Brownsboro, Four-mile Lake (Klamath County), and the Rogue River.

Dendrocopos pubescens. Downy Woodpecker.

Specimens: Eagle Point, male, February 10, 1926; 12.9 km SW Prospect, male, December 16, 1932. This small woodpecker is a fairly common permanent resident of the Rogue River and Bear Creek valleys and foothill stream valleys. Gabrielson and Jewett (1940) list a specimen taken at Medford May 21, 1919.

Dendrocopos nuttallii. Nuttall's Woodpecker.

This woodpecker is known to Jackson County only by the collection of a male and female in the vicinity of Ashland on February 3, and February 4, 1881 (Short 1965). Gabrielson and Jewett (1940) cite a specimen taken in the Umpqua Valley in August 1855, and these authors suggest that it is possible that this species may occur in outhern Oregon near the California-Oregon State line. The A.O.U. Check-list (1957:328) gives southern Humboldt County, California, as the species' northern limit.

Dendrocopos albolarvatus. White-headed Woodpecker.

The White-headed Woodpecker is a rare permanent resident. There are two summer records in Jackson County: One was seen in Mixed Conifer Forest between Fish Lake and Willow Creek Reservoir on July 19, 1961, and one was observed chasing a Yellow-bellied Sapsucker in a ponderosa pine forest near Jenny Creek (extreme southeastern part of the county) on June 16, 1967. Stevenson and Fitch (1933) saw a male on December 16, 1932, in yellow pine at Lake of the Woods in the Cascade Mountains. Gabrielson and Jewett (1940) reported this species in mixed yellow pine and oak in northern Jackson County in the vicinity of Crater Lake National Park (probably north of Union Creek), the Siskiyou Mountains, and Rustler Peak (Cascade Mountains). Farner (1952) considers this woodpecker to be a rare summer resident in Crater National Park.

Picoides arcticus. Black-backed Three-toed Woodpecker.

Specimen: 16.1 km E and 4.8 km N Ashland, male, May 1, 1960. The only recent records of this rare species are from Gardner Reservoir and near Wagner Butte (1,829 m) where one individual was seen on June 11, 1956, and March 15, 1961, respectively. Gabrielson and Jewett (1940) list the summit and western slope of the Cascades, and the Siskiyou Mountains in Jackson County as part of this woodpecker's permanent range.

Picoides tridactylus. Northern Three-toed Woodpecker.

The Northern Three-toed Woodpecker is rare and is known from two sight records. One was observed near Mount Ashland on May 18, 1962, and one on the northern slope of Roxy Ann Peak on December 28, 1962. Gabrielson and Jewett (1940) list the Canadian Life Zone (=True Fir Forest?) of the Siskiyou Mountains for this species' range and consider it a permanent resident.

Tyrannus tyrannus. Eastern Kingbird.

This species is an occasional rare summer resident in the Hoover's Lakes area. Two Eastern Kingbirds were seen there on June 25, 1959, one on June 6, 1960, one May 27, 1961, and one May 30, 1962. A pair was reported near Ashland during June 1964. Gabrielson and Jewett (1940) consider this kingbird to be a common summer resident east of the Cascades.

Tyrannus verticalis. Western Kingbird.

Specimen: 19.3 km N Medford, male, May 5, 1961. The Western Kingbird is a common summer resident and breeding species in the

Chaparral-Oak Community. Earliest, April 17, Phoenix; latest, about late August. An extremely late bird was seen on November 14 at Talent.

Myiarchus cinearascens. Ash-throated Flycatcher.

Specimen: 12.9 km SW Prospect, sex ?, June 18, 1960. This flycatcher is a common summer resident occurring along valley streams and foothills up to about 762 m. Earliest, May 4, Little Butte Creek (near Eagle Point); latest, mid-September, Medford.

Sayornis nigricans. Black Phoebe.

Photographs: Applegate River near Ruch, June 19, 1963 (DT) same location, July 1963 (JH). This phoebe is a rare regular summer resident. A pair of Black Phoebes was discovered nesting under a bridge near the Applegate River not far from Ruch in 1953, and a pair has been observed nesting there annually to this date. Richardson and Sturges (1964) discuss records from Medford, Ashland, and Grants Pass (Josephine County). Evenden et al. (1947) report a sight record of one from Linn County on May 24, 1936, and Jewett (1942) reports the only Oregon specimen, which was collected at Mercer (Lane County) June 1, 1936. Earlier records are discussed by Gabrielson and Jewett (1940:605), who placed the Black Phoebe on the Oregon hypothetical list. The earliest normal date for Jackson County is February 14; latest, September 4, both on the Applegate River near Ruch. Single nonbreeding birds have been observed at Ashland on March 26, 1962, at Trail during most of October 1964, and near Talent in March and May 1971. One was observed near Gold Ray Dam on Bear Creek on January 2 and 3, 1971.

Sayornis saya. Say's Phoebe.

Specimen: 12.9 km SW Prospect, female, March 7, 1947. The Say's Phoebe is a winter visitor and spring migrant in the Chaparral-Oak Community that arrives in late November and leaves in late March It is reported infrequently on Medford CBCs in numbers up to three on any one count.

Empidonax flycatchers.

I have combined the available data of this genus because of the difficulty of accurately identifying these flycatchers. According to sight records five species of this genus have occurred in Jackson County in recent years, most of them regularly. The species reported are: *Empidonax traillii* (Willow Flycatcher), *E. hammondii* (Hammond's), *E. oberholseri* (Dusky), *E. wrightii* (Gray), and *E. difficilis* (Western). Earliest date for any *Empidonax*, April 27, Medford latest, September 23, Medford. Until an adequate series of specimens are collected, the status of the species in Jackson County can be only stated in general terms.

Contopus sordidulus. Western Wood Pewee.

Specimens: Four, Prospect area, May and June. The Western Wood ewee is a common summer resident throughout most of the County om late April to early September.

Nuttallornis borealis. Olive-sided Flycatcher.

Specimens: 12.9 km SW Prospect, male and female, May 29, 1947, nd May 20, 1944, respectively. The Olive-sided Flycatcher is a fairly ommon to common summer resident in the True Fir Forest, and an ncommon migrant in the Rogue River and Bear Creek valleys. Earliest, April 30; latest, mid-September.

Eremophila alpestris. Horned Lark.

The Horned Lark is a fairly common permanent resident in the White City area. The rocky grassland that Gabrielson and Jewett 1940) described as habitat for this species east of Medford probably ncludes the area north of Medford to White City and east towards Gardner Reservoir.

Tachycineta thalassina. Violet-green Swallow.

Specimens: 12.9 km SW Prospect, female, July 18, 1952; N White City, male, February 27, 1971. This swallow is a very common migrant nd summer resident. The species has been reported breeding at Payne Cliffs near Tombstone, both Table Rocks, and Pompadour Bluffs. Earliest, February 11, Game Ponds; latest, October 7, Medford.

Iridoprocne bicolor. Tree Swallow.

The Tree Swallow is a very common migrant and summer resident, breeding throughout most of the county. Earliest, February 7, Game Ponds; latest, October 4, Medford. Spring migrants often use Bear Creek as a flyway, and as many as several thousand may be seen daily in early April. Gabrielson and Jewett (1940) report that there was a colony utilizing dead trees drowned by the newly formed Fish Lake. The dead snags have subsequently been removed from reservoirs (see Purple Martin account).

Riparia riparia. Bank Swallow.

The Bank Swallow is an uncommon summer resident reported as a migrant from Medford, Phoenix, Ashland, Prospect, and Trail. A breeding colony of six individuals was discovered at McCloud on the Rogue River throughout the spring of 1963. To my knowledge there is only one published record of this species breeding in Oregon west of the Cascades (Gabrielson and Jewett 1940).

Stelgidopteryx ruficollis. Rough-winged Swallow.

Specimen: 12.9 km SW Prospect, female, May 19, 1947. The Rough-winged Swallow is an uncommon summer resident and migrant. It is slightly more abundant and more widely distributed than the Bank Swallow. This swallow breeds along streams below

610 m where soft sandy stream banks are to be found. Earliest arrival February 24, Phoenix; latest departure, September 28, Medford.

Hirundo rustica. Barn Swallow.

This fork-tailed species is a fairly common migrant and summer resident in the Chaparral-Oak Community and Mixed Forest below 914 m. Earliest, April 6, Medford; latest, October 10, Medford. During the breeding season single pairs may be found nesting under almost every one of the many irrigation bridges scattered throughout the lower elevations of Jackson County.

Petrochelidon pyrrhonota. Cliff Swallow.

Specimens: 12.9 km SW Prospect, two females, May 5 and 19 1947. This species is a common migrant and summer resident. Earliest March 23, Game Ponds; latest, mid-September. The Cliff Swallow breeds on cliff faces and barns, probably throughout the Chaparral-Oak Community and Mixed Conifer Forest below about 914 m.

Progne subis. Purple Martin.

This species is an uncommon summer resident that formerly nested in dead snags on the shore of Hyatt Reservoir until the snags were removed about 1960. The Purple Martin is occasionally observed during summer at Howard Prairie Reservoir where it is thought to breed. Migrants are occasionally observed at lower elevations. Earliest, April 25, Shady Cove; latest, probably September.

Perisoreus canadensis. Gray Jay.

The Gray Jay is an uncommon permanent resident in the Mixed Conifer and True Fir forests of the Cascade and Siskiyou mountains The only known breeding record of the Gray Jay in Jackson County is from Fish Lake where an adult was observed feeding fledged young in August 1967. It occurs at lower elevations during winter.

Cyanocitta stelleri. Steller's Jay.

Specimens: Six, 12.9 km SW Prospect, both sexes, January, February, May, October, and December. This jay is a fairly common permanent resident throughout Mixed Conifer Forest and low elevations in True Fir Forest. The Steller's Jay has been found breeding as low as 594 m at Ashland. This species is an uncommon winter resident in the Lower Rogue River and Bear Creek valleys.

Aphelocoma coerulescens. Scrub Jay.

Specimens: Ashland, male and female, November 1, 1964. The Scrub Jay is a common permanent resident in the Chaparral-Oak Community and Mixed Conifer Forest below 914 m. It breeds throughout its range.

Pica pica. Black-billed Magpie.

Photograph: Ashland, one bird, May 30, 1963 (DT). An irregula visitor, small numbers of the Black-billed Magpie occur nea

Pompadour Bluffs in summer. Six were at Ashland on November 20, 1960, and two were reported on a Medford CBC (*Aud. Field Notes* 1962:276) on December 28, 1961. The species is also occasionally seen on the west slope of Baldy during the summer. It possibly breeds in the extreme southeastern part of the county.

Corvus corax. Common Raven.

Specimen: 12.9 km SW Prospect, sex?, November 16, 1955. The Common Raven is an uncommon permanent resident in the Mixed Conifer Forest. Ravens have been seen at Union Creek, Butte Falls (on Big Butte Creek, 773 m), and at Howard Prairie and Willow Creek reservoirs.

Corvus brachyrhynchos. Common Crow.

Specimen: 12.9 km SW Prospect, male, April 1, 1954. The Common crow is an uncommon permanent resident throughout Jackson County, except in coniferous forests where it is rare. Crows are most commonly observed in the foothills of the Lower Rogue River and Bear Creek valleys and foothills east of Ashland.

Nucifraga columbiana. Clark's Nutcracker.

Specimens: 19.3 km NE Trail, male, date?; Mount Ashland, male, July 2, 1962. The species is an uncommon permanent resident in the Cascade and Siskiyou mountains. Browning (1966a) discusses summer records from the Siskiyou Mountains near Mount Ashland, including a sight record of a pair with one fledgling seen on July 25, 1965, at about 2,134 m. All reports of this species are from areas above 1,829 m.

Parus atricapillus. Black-capped Chickadee.

Specimen: 3.2 km S Medford, male, May 24, 1969. This chickadee is a common permanent resident that is most often found in the Lower Rogue River and Bear Creek valleys.

Parus gambeli. Mountain Chickadee.

Specimen: 4.8 km SW Ashland, male, November 23, 1969. The Mountain Chickadee is a permanent resident in the county. It breeds in Mixed Conifer and True Fir forests above about 1,067 m. The species winters sparingly in the Rogue River and Bear Creek foothills.

Parus rufescens. Chestnut-backed Chickadee.

Specimens: Four from near Prospect, both sexes, two taken in March, one in February, and one in November. This chickadee is an uncommon permanent resident in the True Fir Forest and to about 1,067 m in the Mixed Conifer Forest. The Chestnut-backed Chickadee winters sparingly in the Lower Rogue River and Bear Creek valleys and foothills.

Parus inornatus. Plain Titmouse.

Specimen: 13.7 km SW Prospect, female, January 10, 1959. The Plain Titmouse is a common permanent resident in the Chaparral-Oak Community.

Psaltriparus minimus. Bushtit.

Specimens: 4.8 km NE Ashland near Emigrant Reservoir, male May 30, 1970. The Bushtit is a very common resident in the Chaparral-Oak Community of the Lower Rogue River and Bear Creek valleys The species remains in flocks during winter, dispersing into pairs by April.

Sitta carolinensis. White-breasted Nuthatch.

Specimens: 12.9 km SW Prospect, sex ?, January 11, 1935; 17.7 km SW Prospect, sex ?, February 10, 1948; Ashland, female, January 8 1968; S side Emigrant Reservoir, female, March 24, 1970. This nuthatch is a common to fairly common permanent resident that breeds throughout most of Jackson County below 1,219 m in oaks and Mixed Conifer Forest. It has been found nesting (eggs) as early as April 29, at Larson Creek.

Sitta canadensis. Red-breasted Nuthatch.

Specimens: Three from near Prospect, both sexes, March and December. The Red-breasted Nuthatch is an uncommon to fairly common permanent resident of the True Fir Forest and winters to the valley foothills.

Sitta pygmea. Pygmy Nuthatch.

This small nuthatch is a rare winter visitor known to have occurred twice in the Lower Bear Creek Valley. The first record of the Pygmy Nuthatch in Jackson County was of five reported on a Medford CBC on December 28, 1953 (*Aud. Field Notes* 1954:211): one was seen December 30, 1958, on a Medford CBC (*Aud. Field Notes* 1959:243). Gabrielson and Jewett (1940) state they have *commonly* (italics mine) found this species in eastern Jackson County.

Certhia familiaris. Brown Creeper.

Specimens: 12.9 km SW Prospect, sex ?, November 28, 1951 Spring Creek (extreme SE Jackson County), male, June 13, 1967 The Brown Creeper is a fairly common breeding bird probably occurring throughout the conifer forests of the county, at least in the Cascade Mountains. This species winters throughout its breeding range and to the valley floor.

Chamaea fasciata. Wrentit.

The Wrentit is an uncommon permanent resident. Gabrielson (1931) reported several colonies of the Wrentit from the Rogue River Valley. Stevenson and Fitch (1933) reported a breeding colony of this species 11.3 km north of Medford. Presently, the Wrentit is own to breed in the foothills in Chaparral-Oak Community south Ashland. Occasionally it is observed on Roxy Ann Peak and in e foothills west of Medford.

Cinclus mexicanus. Dipper.

Specimens: Prospect, female, March 10, 1935; 12.9 km SW Prospect, ale, January 9, 1935. The Dipper is a fairly common resident equenting mountain streams throughout most of the county except the Chaparral-Oak Community of the Lower Rogue River and ear Creek valleys.

Troglodytes aedon. House Wren.

Specimens: 12.9 km SW Prospect, male, April 30, 1947; 9.7 km SW rospect, male, April 26, 1944. The House Wren is a common summer esident. This wren breeds throughout the county, but more frequently it is found in the valley foothills and mountains in Mixed onifer Forest. Earliest, April 26, near Prospect; probably leaves y late September or early October.

Troglodytes troglodytes. Winter Wren.

Specimens: Prospect, two males, September 15, 1934, and Deember 26, 1933. This small wren is a fairly common permanent esident in the True Fir Forest that may be found in the valley reas in winter where it often frequents riparian understory.

Thryomanes bewickii. Bewick's Wren.

The Bewick's Wren is a common permanent resident that is most ften found in the Chaparral-Oak Community of Jackson County.

Telmatodytes palustris. Long-billed Marsh Wren.

Specimen: NE Medford, male, January 1971. Until recent years this arsh wren was considered a rare winter visitor. This wren has been onsidered common since the fall of 1963 and is regularly found in arsh habitat of the Lower Rogue River and Bear Creek valleys. It as been observed at the Game Ponds as late as June. Singing and territorial disputes at the latter location have been observed, although breeding has not been confirmed.

Catherpes mexicanus. Cañon Wren.

Specimen: Jenny Creek, extreme SE Jackson County, female, May 28, 1966. The Cañon Wren is an uncommon breeding bird in the county. All sight records of the species have been made in the eastern part of Jackson County. It has been observed on occasion at Fish Lake and once during August at Grizzly Creek (near Fish Lake). The female taken on May 28, 1966, was in breeding condition and was observed carrying food to a rimrock crack. Gabrielson and Jewett (1940) state that this wren crosses the Cascade Mountains to Jackson County and list a male taken at Ashland on February 21, 1924.

Salpinctes obsoletus. Rock Wren.

Specimen: 1.6 km E Prospect, male, April 2, 1947. The Rock Wren is a fairly common summer resident and breeding bird at Pompadour Bluffs, both Table Rocks, and possibly elsewhere in similar habitat, although there are only two records of this species in other areas. One was observed at Ashland on February 10, 1964, and one at Emigrant Reservoir April 18, 1964.

Mimus polyglottos. Mockingbird.

Rare. Single individuals have been reported at Medford in 1958 and 1961–63 in March, April, November, and December, in 1970 in February through mid-March and May, at Phoenix in April 1963, and at Ashland in February 1965. Hyde (1940) reported one seen at Burns on May 25, 1940, and Sooter (1941) lists two from Malheur National Wildlife Refuge (Harney County) seen on July 25, and August 23, 1940. Fender (1951) and Walker (1955) report spring records from McMinnville and Nehalm Bay in western Oregon. Gabrielson and Jewett (1940) give the Steens Mountains (Harney County) as the known range in Oregon.

Toxostoma redivivum. California Thrasher.

Accidental. One stayed near a feeder 8.1 km west of Medford (Chaparral-Oak) from July 24 to October 20, 1967, and a bird was seen at the same feeder on February 4 to 25, 1968. The A.O.U. Check-list (1957) gives southern Humboldt, Trinity, and Shasta counties, California, as the northern limit of this species' range.

Toxostoma lecontei. Le Conte's Thrasher.

Accidental. One Le Conte's Thrasher was observed on the western slope of Pilot Rock (about 19.3 km southeast of Ashland) at 1,524 m in the Siskiyou Mountains on July 29, 1966, by three persons (*Aud. Field* Notes 1966:594). Central California is this species' northern range limit (A.O.U. 1957:428).

Turdus migratorius. American Robin.

Specimens: Several from various localities and dates. The American Robin is a very common permanent resident throughout most of the county, increasing in numbers during the winter when roosts are formed. The largest roost reported contained about 30,000 birds near Gold Ray Dam during 1964–65. Robins breed throughout most of the county.

Ixoreus naevius. Varied Thrush.

Specimens: 12.9 km SW Prospect, two males December 1933, one male November 1934; 19.3 km NE Trail, sex ?, March 10, 1926. The Varied Thrush is a common to uncommon winter resident that possibly breeds in the Cascades. During winter this thrush frequents the valley in fluctuating numbers.

Catharus guttatus. Hermit Thrush.

Specimens: Four specimens from Prospect, two in April, two in December; both sexes. The Hermit Thrush is a fairly common breeding bird and uncommon winter resident. The species breeds in the Mixed Conifer and True Fir forests. The lowest elevation for apparent breeding is indicated by a record of a singing male in Yank Gultch, outhwest of Talent, at 732 m, on June 26, 1960. It arrives in Jackson County in late April and normally departs in late September.

Catharus fuscescens. Veery.

The Veery is a rare migrant or visitor. The species was first reported n Jackson County in 1964 when one was observed near Shady Cove on May 24. One was seen at Talent on May 6, 1964, and one near Shady Cove May 28–29, 1965. Single birds were reported near Shady Cove n the summers of 1968, 1969, and 1970. There are several records from eastern Oregon (Gabrielson and Jewett, 1940).

Sialia mexicana. Western Bluebird.

Specimens: Four of both sexes near Prospect, February and March; Eagle Point, female, November 26, 1925; 19.3 km NE Trail, male, March 6, 1926. The Western Bluebird is a common to fairly common permanent resident. This bluebird frequents oak woodlands and some open conifer forests of the Chaparral-Oak Community and the Mixed Conifer Forest. It is most commonly observed in the foothills of the Lower Rogue River and Bear Creek valleys. Winter populations during 1962 were greatly reduced during a week of temperatures near −17 C.

Sialia currucoides. Mountain Bluebird.

Photographs: White City, February 1962 (JH); near Old Military Bridge, March 17, 1964 (DT). The Mountain Bluebird is an uncommon breeding bird in the True Fir Forest of the Cascade and Siskiyou mountains. The species is a rare irregular winter visitor to the Lower Rogue River and Bear Creek valleys.

Myadestes townsendi. Townsend's Solitaire.

Specimens: 12.9 km SW Prospect, female, April 3, 1947, male June 30, 1951. Gabrielson and Jewett (1940) report numerous records from the eastern part of the county in the valley foothills. Gabrielson collected an immature barely able to fly on the western base of Mount McLoughlin on July 27, 1926. Recent records of this thrush suggest that it breeds in the high Cascades and probably in the Siskiyou Mountains of the True Fir Forest. During fall and winter this species occasionally wanders to the foothills east of Bear Creek, and it has been reported at Ashland and at Hoover's Lakes in the spring.

Polioptila caerulea. Blue-gray Gnatcatcher.

Photographs: Roxy Ann Peak, June 1963 (JH); June 6, 1963 (DT). This species has bred in Jackson County for a number of years. Breeding was confirmed by the location of a nest on Roxy Ann Peak during the spring of 1963 (Richardson and Sturges 1964). During that year the nesting pair was unsuccessful in raising young. Since then, the Blue-gray Gnatcatcher has been observed breeding on Roxy Ann Peak and near Ashland. Four pairs of gnatcatchers were observed on Roxy Ann Peak in 1970 and six pairs in 1971 with one nest found each year. Earliest, May 7, Gardner Reservoir; latest, June 27, Roxy Ann Peak. Undoubtedly the departure date for this species is much later than indicated from available observations.

Gabrielson and Jewett (1940) do not list the Blue-gray Gnatcatcher for Oregon. Pruitt (1950) reports two records from Lane County, six near Thurston on April 26, 1949, and one at Eugene on May 26 to June 2, 1949. The normal range of this species extends north to Trinity and Siskiyou counties, immediately to the south of Jackson County (A.O.U. 1957:450).

Regulus satrapa. Golden-crowned Kinglet.

Specimen: 19.3 km NE Trail, male, March 7, 1926. The Golden-crowned Kinglet is a common permanent resident throughout the True Fir Forest of the county. It is occasionally found in the Lower Rogue River and Bear Creek valleys during winter.

Regulus calendula. Ruby-crowned Kinglet.

Specimens: Four from near Prospect, both sexes, January and March. This kinglet is a common permanent resident throughout most of Jackson County. The species breeds in Mixed Conifer Forest and possibly True Fir Forest and winters in the low elevations of the former and the Chaparral-Oak Community.

Anthus spinoletta. Water Pipit.

Specimens: Four taken near Prospect, both sexes, three in March, one in October. The Water Pipit is a common to fairly common fall migrant and winter resident. Earliest, July 12, Phoenix; latest, April. In winter pipits are most often seen at Hoover's Lakes.

Bombycilla garrulus. Bohemian Waxwing.

Specimen: Near Ashland, female, May 13, 1969. This waxwing is a rare irregular winter visitor to Jackson County with sight records from Medford in December, January, and February.

Bombycilla cedrorum. Cedar Waxwing.

Specimens: Eight, 12.9 km SW Prospect, both sexes, January, June, and November. The Cedar Waxwing is a very common and fairly regular migrant and permanent resident in most of Jackson County. It is abundant in Bear Creek Valley during some springs.

Phainopepla nitens. Phainopepla.

Accidental. This species has occurred once in Jackson County where bird was observed at Barneburg Hill south of Medford on March 15, 961 (Browning 1966b). Marshall (1959) collected one Phainopepla 6.1 km north of Frenchglen (Harney County) on May 17, 1957, pparently the first Oregon specimen.

Lanius excubitor. Northern Shrike.

Specimen: Central Point, female, January 18, 1970. The Northern Shrike is a fairly regular winter visitor in the Lower Rogue River nd Bear Creek valleys and foothills. This shrike has been recorded n 4 of 13 Medford CBCs and the highest count was two individuals. The species arrives in September and departs in April.

Lanius ludovicianus. Loggerhead Shrike.

This shrike is an uncommon permanent resident of the Lower Rogue River and Bear Creek valleys; most often seen in winter. Jewett collected one at Medford on March 19, 1934 (Gabrielson and Jewett 1940). These authors consider the Loggerhead Shrike to be rare west of the Cascade Mountains.

Sturnus vulgaris. Starling.

Specimen: 12.9 km SW Prospect, female, December 26, 1958. The Starling was first observed in Jackson County on February 8, 1954. It now breeds throughout the county below 610 m and is considered a very common breeding species. In winter the population increases in number when this species is considered a common to abundant winter resident.

Vireo huttoni. Hutton's Vireo.

Specimen: 12.9 km SW Prospect, sex ?, December 1, 1948. The Hutton's Vireo is a rare to common permanent resident. Six eggs of this vireo and five eggs of Brown-headed Cowbird (*Molothrus ater*) were found in a nest near Medford on July 9, 1965. The nest and eggs are deposited at Southern Oregon College.

Vireo solitarius. Solitary Vireo.

Specimens: 12.9 km SW Prospect, male, May 19, 1944; 17.7 km SW Prospect, male, May 19, 1947. The Solitary Vireo is a common summer resident throughout most of the county in Mixed Conifer Forest along streams. Earliest, March 19, Medford; latest November 11, Phoenix.

Vireo olivaceus. Red-eyed Vireo.

This vireo is a rare and irregular migrant and summer visitor from May to September (Browning 1966a). Kridler (1965) has records for May, June, August, and September from southeastern Oregon near Burns (Harney County). The A.O.U. Check-list (1957) gives northern Oregon as the southern limit of this vireo's normal range.

Vireo gilvus. Warbling Vireo.

Specimen: Ashland, male, May 18, 1955. The Warbling Vireo is a common summer resident in Mixed Conifer Forest throughout the county. Earliest, April 18, Ashland; latest September 19, Medford.

Mniotilta varia. Black and White Warbler.

This eastern warbler was observed at Talent on October 7, 1963. Kridler and Marshall (1962) took a female at Malheur National Wildlife Refuge (Harney County) on September 17, 1960, the first specimen for Oregon.

Vermivora peregrina. Tennessee Warbler.

Accidental. An immature Tennessee Warbler was observed feeding with a migrant flock of Orange-crowned (*Vermivora celata*) and Wilson's Warblers (*Wilsonia pusilla*), and Warbling Vireos (*Vireo gilvus*) near Shady Cove on September 11, 1969. This species was reported the same year from Terrace, western British Columbia on August 14 (*Aud. Field Notes* 1969:88). Littlefield and Anderson (1971) list 11 records of the Tennessee Warbler in Oregon; nine have been recorded at Malheur National Wildlife Refuge (Harney County), and one from the Wallowa Mountains (northeastern Oregon) in addition to the Jackson County record. Littlefield and Anderson (1971) regard the species as an occasional spring and fall migrant in southeastern Oregon. The Tennessee Warbler is listed as a rare straggler in eastern Washington (Larrison and Sonnenberg 1968) with no spring records. In California the species is considered a regular but rare fall migrant (*Aud. Field Notes* 1970:94; *Am. Birds* 1971: 104–105).

Vermivora celata. Orange-crowned Warbler.

Specimens: Four, 12.9 km SW Prospect, both sexes, April and May. The Orange-crowned Warbler is a regular and common summer resident and migrant and is a fairly regular winter resident in the Lower Rogue River and Bear Creek valleys. This warbler has been reported in the county in almost every month, but is most numerous between mid-April to late September when it may be found in the Chaparral-Oak Community. Jewett found it nesting at Goldhill on May 16, 1916 (Gabrielson and Jewett 1940).

Vermivora ruficapilla. Nashville Warbler.

Specimens: Four, SW Prospect, both sexes, April and May. The Nashville Warbler is a common summer resident in the Mixed Conifer Forest. Earliest, April 20, Ashland; latest, August 28, Phoenix.

Dendroica petechia. Yellow Warbler.

The Yellow Warbler is a common summer resident throughout most of Jackson County, especially wooded streams below 914 m. Earliest, April 28, Pompadour Bluffs; latest, September 17, Medford.

Dendroica coronata. Yellow-rumped Warbler.

The yellow-throated subspecies, *auduboni*, and the white-throated ubspecies, *coronata*, are generally easy to distinguish in the field so hey are treated separately here.

Dendroica coronata coronata. Fairly common migrant and uncommon winter resident. This subspecies is reported most often in the Lower Rogue River and Bear Creek valleys. Spring migration peaks rom April 1 to 15. One or two nominate *coronata* are recorded annually n the Medford CBCs.

Dendroica coronata auduboni. Specimens: Three, 12.9 km SW Prospect, male, April 10, 1946, female April 11, 1946, and male May 29, 934; 4.8 km N Prospect, female, June 8, 1934. The yellow-throated ubspecies is a fairly common permanent resident that breeds in the mountains in Mixed Conifer and True Fir forests and winters in the valley areas. During spring migration the number of birds increases between April 1 and 15 in the valley.

Dendroica nigrescens. Black-throated Gray Warbler.

Specimen: 3.2 km S Medford, male, May 24, 1969. This mountain warbler is an uncommon migrant and summer resident. During migration it may be found throughout the county. In summer it breeds in the Mixed Conifer Forest of the Cascades and probably the Siskiyou Mountains. Earliest, March 31; latest, October 7, Medford.

Dendroica townsendi. Townsend's Warbler.

Specimen: 12.9 km SW Prospect, male, July 23, 1949. The Townsend's Warbler is an uncommon migrant and winter visitor. There are only two summer records of this warbler in Jackson County, the specimen cited and a bird observed on Roxy Ann Peak on August 20, 1961. The latter was probably an early fall migrant. Earliest, April 30, Ashland; latest, October 11, Larson Creek. Wintering birds or winter visitors have occurred in the Medford area in November, December, and January.

Dendroica occidentalis. Hermit Warbler.

The Hermit Warbler is an uncommon migrant in the foothills and mountains that probably breeds in coniferous areas of the county. A pair nested at Ashland in 1962 at 610 m, far below normal breeding altitudes. The species arrives in the county in late April and departs in late August.

Seiurus noveboracensis. Northern Waterthrush.

Accidental. There are two sight records of this warbler in Jackson County; one was near Shady Cove on May 30, 1964, and one at the same location on August 16, 1970. Gabrielson and Jewett (1940) cite the first specimen collected in Oregon, a bird at Beaver (Tillamook County) on August 26, 1931. Kridler (1965) collected a female

Northern Waterthrush at Malheur National Wildlife Refuge (Harney County) on May 9, 1961, and another was seen there on December 21 1963 (*Aud. Field Notes* 1964:376).

Oporornis tolmiei. MacGillivray's Warbler.

Specimens: Four, 12.9 km SW Prospect, both sexes, various dates in May; Ashland, male, May 4, 1969. The MacGillivray's Warbler is a fairly common summer resident throughout most of the county in brushy areas of the foothills and mountains below 1,219 m. Earliest April 19, Medford; the species departs in early October.

Geothlypis trichas. Yellowthroat.

The Yellowthroat is an uncommon migrant and summer resident It may be found in suitable habitat below 914 m. Earliest, April 19 Medford; latest, October 1, Medford.

Icteria virens. Yellow-breasted Chat.

Specimens: 12.9 km SW Prospect, male, May 17, 1947, and sex ? June 9, 1947. The chat is a common summer resident along streams in the Chaparral-Oak Community. Earliest, April 24, Phoenix; latest September.

Wilsonia pusilla. Wilson's Warbler.

Specimens: 12.9 km SW Prospect, male, May 6, 1944; Ashland male, 1971. This warbler is a common summer resident, breeding in Mixed Conifer Forest of the Cascade Mountains. Earliest, April 16 Medford; latest late September, Bear Creek Valley.

Setophaga ruticilla. American Redstart.

The American Redstart is a rare breeding species. A pair with fou young was discovered in deciduous forest along the Rogue River nea Shady Cove on July 2, 1970 (Bertrand et al. 1973). Kridler and Marshall (1962) report collecting a female at Malheur National Wildlife Refuge (Harney County) on September 8, 1960. There are two sight records at Medford; a male and female in May 1957, and a male in May 1962. Gabrielson and Jewett (1940) consider the redstart to be a casual migrant and possible summer resident of the Blue Mountain district of northeastern Oregon.

Passer domesticus. House Sparrow.

Specimens: 12.9 km SW Prospect, male, April 16, 1951; Ashland female, February 5, 1961. This species is a common permanent resident throughout Jackson County near human dwellings.

Sturnella neglecta. Western Meadowlark.

Specimens: Agate Desert near White City, male, December 30 1934; 12.9 km SW Prospect, April 15, 1949. The Western Meadowlark is a very common permanent resident throughout the Chaparral Oak Community. A few birds occur in the open grasslands of th Mixed Conifer Forest below 762 m.

Xanthocephalus xanthocephalus. Yellow-headed Blackbird.

This blackbird is an uncommon summer resident and occasional winter visitor near White City. Two to five pairs of the species breed at the Game Ponds. It probably breeds at nearby Hoover's Lakes. Gabrielson and Jewett (1940) consider the species to be an irregular visitor west of the Cascades.

Agelaius phoeniceus. Red-winged Blackbird.

Specimens: Four, near Prospect, both sexes, March, April, May, and August. The Red-winged Blackbird is a very common permanent resident below 762 m. The species breeds along the Lower Rogue River and Bear Creek and tributaries and marsh edges of ponds and valley reservoirs. It is an abundant winter resident in the valley floor.

Agelaius tricolor. Tricolored Blackbird.

Specimens: Six, 1.6 km NW White City, three males and three females, June 2, 1960. The Tricolored Blackbird was formerly thought to be found in Oregon only in Klamath County (Gabrielson and Jewett 1940). In the summer of 1956 Richardson (1961) saw 15 to 20 in Medford and in May 1957 he saw several hundred 4.8 km east of Medford. Thomas McCamant discovered the species nesting east of Central Point on June 2, 1958 (*Aud. Field Notes* 1958:379). Richardson (1961) collected three nests with three eggs each, and also the three males and three females cited. The marsh at the White City collection locality was drained in 1961, but a colony was located 1.6 km east of Eagle Point (Richardson and Sturges 1964). On the basis of these records and winter occurrences, the Tricolored Blackbird is now considered a very common local permanent resident in Jackson County.

Icterus cucullatus. Hooded Oriole.

Accidental. Two adult males with an immature or adult female were seen at Ashland on May 15, 1963, and a male and female were observed south of Ruch on October 1, 1964 (Browning 1966b). A female was reported at Malheur National Wildlife Refuge (Harney County) on May 29, 1964 (*Aud. Field Notes* 1964:475) and a male was observed at the south jetty of the Columbia River on April 26, 1969 (*Aud. Field Notes* 1969:618). The A.O.U. Check-list (1957) gives central California as the Hooded Oriole's northern range limit.

Icterus galbula. Northern Oriole.

Specimen: 12.9 km SW Prospect, sex ?, April 29, 1959; Roxy Ann Peak, male, May 10, 1970. The Northern Oriole is a common migrant and breeding species in the Chaparral-Oak Community. Earliest, March 22, Medford; latest, October 29, Medford.

Euphagus cyanocephalus. Brewer's Blackbird.

Specimens: Two, 1.6 km E Prospect, female, April 12, 1947, and male, March 29, 1947; 9.7 km N Prospect, female, April 27, 1935; Ashland, two males, May 7 and 25, 1968. This blackbird is a very common permanent resident and breeding species in the Chaparral-Oak Community and Mixed Conifer Forest.

Molothrus ater. Brown-headed Cowbird.

Specimens: Four, 12.9 km SW Prospect, both sexes, in May, June, and July. The Brown-headed Cowbird is a fairly common summer resident and an uncommon winter resident in Jackson County. It occurs with mixed flocks of blackbird species in the valley during winter. In spring the cowbird population increases and the species disperse throughout most of the county, especially to the Mixed Conifer Forest. Gabrielson and Jewett (1940) consider the species a rare straggler to western Oregon on the basis of a specimen collected in Lane County in 1925 (Jewett 1930) and a specimen collected there in 1930. Thatcher (1953) collected an immature bird in Medford on July 11, 1950, and suggested that Jackson County offers a suitable breeding habitat for the Brown-headed Cowbird. Specimen evidence and observed territorial displays substantiate this species as a breeding bird in Jackson County.

Piranga ludoviciana. Western Tanager.

Specimens: Seven, 12.9 km SW Prospect, both sexes, in May, June and September. The Western Tanager is a common migrant in th Lower Rogue River and Bear Creek valleys and common summe resident in Mixed Conifer and True Fir forests. Earliest, April 9 Jacksonville; latest September 19, Medford.

Pheucticus melanocephalus. Black-headed Grosbeak.

Specimens: Three, 12.9 km SW Prospect, both sexes, May an June. This species is a common summer resident in the Lower Rogu River and Bear Creek valleys; it arrives in early April and departs i late September. It is fairly common in Mixed Conifer Forest at leas near Ashland and Jacksonville.

Passerina amoena. Lazuli Bunting.

Specimens: 3.2 km SW Prospect, male, June 1, 1935; 12.9 km S Prospect, sex ?, June 11, 1946. The Lazuli Bunting is a fairly commo summer resident in the Chaparral-Oak Community. Earliest, April 3 Larson Creek; latest, early September, Bear Creek Valley.

Hesperiphona vespertina. Evening Grosbeak.

Specimens: 12.9 km SW Prospect, male and female, February 1949; Ashland, male, May 27, 1971. The Evening Grosbeak is a fair common permanent resident occurring sporadically throughout mo of Jackson County. The species frequents the Chaparral-Oak Con unity in winter and spring and is occasionally seen in the Cascades Mixed Conifer Forest during summer. There is one unconfirmed port of the Evening Grosbeak breeding in the Siskiyou Mountains nd Gabrielson and Jewett (1940) report a single breeding record from e western base of Mount McLoughlin.

Carpodacus purpureus. Purple Finch.

Specimens: Ten, near Prospect, both sexes, January, April, May, nd June; Ashland, male, February 9, 1924, female, February 27, 1966. he Purple Finch is a fairly common permanent resident in the Mixed onifer and True Fir forests of the county. It visits low elevations uring winter.

Carpodacus cassinii. Cassin's Finch.

Specimens: Prospect, one male, two females, November 4, 1935. his finch is a fairly common permanent resident that breeds in the rue Fir Forest of Jackson County, especially in the Cascades. It isits low elevations during winter.

Carpodacus mexicanus. House Finch.

Specimen: 12.9 km SW Prospect, sex ?, June 9, 1947. The House inch is a common permanent resident in the Chaparral-Oak Com- unity, decreasing slightly in numbers during winter. It breeds rimarily in residential locations.

Pinicola enucleator. Pine Grosbeak.

The Pine Grosbeak is an irregular and rare spring visitor. This ecies has occurred in Jackson County on three occasions: one each ear Howard Prairie Reservoir on May 30, 1960, and on May 30, 1965, nd one was reported east of Mount Ashland on June 30, 1961 Browning 1966b). Gabrielson and Jewett (1940) consider the species o be an irregular winter visitor to eastern Oregon.

Leucosticte tephrocotis. Gray-crowned Rosy Finch.

This species possibly breeds on Mount McLoughlin. Vernon ailey (*in* Gabrielson and Jewett 1940) saw a flock of 20 birds above mberline on Mount McLoughlin between August 23 and 30, 1916. here are no recent records from the county.

Spinus pinus. Pine Siskin.

Specimens: Two, 12.9 km SW Prospect, females, April 14, 1947, and ay 1, 1946; Ashland, male and female, May 10, 1964. The Pine iskin is a common permanent resident in the Mixed Conifer Forest. t occasionally winters in the Lower Rogue River and Bear Creek alleys and is common there during spring and fall.

Spinus tristis. American Goldfinch.

Specimens: Two, 12.9 km SW Prospect, male, April 21, 1959, female, ay 1, 1947. This goldfinch is a common permanent resident in the

Chaparral-Oak Community of the county. In winter it may be found with flocks of Lesser Goldfinches (*Spinus psaltria*).

Spinus psaltria. Lesser Goldfinch.

Specimen: 12.9 km SW Prospect, female, April 21, 1959. The Lesser Goldfinch is a permanent resident in the Chaparral-Oak Community of the Lower Rogue River and Bear Creek valleys. The species is slightly less common than the American Goldfinch (*Spinus tristis*). In winter it may be found with flocks of the latter species.

Spinus lawrencei. Lawrence's Goldfinch.

Photograph: Talent, fall 1962 (DT). This species is a very rare occasional visitor. One bird was captured in Medford on April 20, 1958, and then released and one was seen near Medford on June 7, 1967. The A.O.U. Check-list (1957) gives north-central California as the northern range limit of this species. Gabrielson and Jewett (1940) do not list the species for Oregon.

Loxia curvirostra. Red Crossbill.

Specimens: Two, 12.9 km SW Prospect, male and female, May 17, 1946. The Red Crossbill is an occasional winter and spring visitor. Sight records of the species have been made at Ruch, Trail, Medford, Gardner Reservoir, Oregon Switzerland, and Prospect. Thirty-nine individuals were recorded on a Medford CBC on December 27, 1956 (*Aud. Field Notes* 1957:221).

Chlorura chlorura. Green-tailed Towhee.

This towhee is a fairly common summer resident along the Cascade summit and east, and in the Siskiyou Mountains in Mixed Conifer Forest (*Pinus ponderosa* edge). Earliest, May 3, Larson Creek; latest, September 23, (Jackson County, *in* Gabrielson and Jewett 1940).

Pipilo erythrophthalmus. Rufous-sided Towhee.

Specimens: Three, 4.8 km SW Prospect, both sexes, January and November; 17.7 km SW Prospect, male, April 30, 1949; Table Rock, male, December 7, 1959; two, near Ashland, both sexes, November 1, 1964. The Rufous-sided Towhee is a common permanent resident in the Lower Rogue River and Bear Creek valleys up to about 762 m, except in the extreme southeastern portion of the county in the Chaparral-Oak Community where it is uncommon.

Pipilo fuscus. Brown Towhee.

Specimens: Two, 25.7 km SW Prospect, male, November 13, 1959, and female, November 11, 1959. The Brown Towhee is a fairly common to uncommon permanent resident in the Chaparral-Oak Community of the Lower Rogue River and Bear Creek valleys and foothills.

Calamospiza melanocorys. Lark Bunting.

Accidental. A male Lark Bunting was seen feeding with a flock of Brewer's Blackbirds at White City on November 13, 1961 (*Aud. Field Notes* 1962:68). An adult male and an immature of this species were reported near Yaquina Head (Lincoln County) on August 6, 1969 (*Aud. Field Notes* 1969: 68). The A.O.U. Check-list (1957) gives central California as the closest casual record to Jackson County.

Passerculus sandwichensis. Savannah Sparrow.

Specimens: Four, near Prospect, both sexes, March and April; Medford, female, February 12, 1965; six, Hoover's Lakes, March, April, and May. The Savannah Sparrow is a common permanent resident and breeds in open grasslands in the Lower Rogue River and Bear Creek valleys. It is a very common spring and fall migrant and is especially numerous during migration in the Agate Desert and in the vicinity of White City.

Ammodramus savannarum. Grasshopper Sparrow.

Photographs: Five, Hoover's Lakes, June 2, 1963 (JH). This species is known only from records of birds observed at Hoover's Lakes during the spring and summer of 1963 where one was discovered on May 30. Two were observed carrying food in the same area on June 2 and 6, but no nest could be located. Lone birds were seen on June 17 and 26, both carrying food. An immature was observed on August 15 in the same area (Richardson and Sturges 1964). Gabrielson and Jewett 1940) list a specimen taken at Robinette (Baker County) on June 22, 1916.

Pooecetes gramineus. Vesper Sparrow.

Specimens: 12.9 km SW Prospect, male, May 24, 1947; Jackson-Klamath County boundary near Pinehurst, sex ?, May 10, 1964. This sparrow is a fairly common summer resident, occurring in the mountains in Mixed Conifer Forest during the breeding season and in the valley during migration. It arrives in late February to March and departs in late September or early October.

Chondestes grammacus. Lark Sparrow.

Specimens: 12.9 km SW Prospect, male, September 22, 1950; 16.1 km SW Prospect, sex ?, May 1, 1946; Ashland, male, June 1, 1968. The Lark Sparrow is a fairly common permanent resident in the Lower Rogue River and Bear Creek valleys and foothills of the Chaparral-Oak Community. It is less common during winter.

Amphispiza bilineata. Black-throated Sparrow.

Accidental. This species has been observed on the south slope of Roxy Ann Peak where it was first discovered on May 30, 1970. Two birds were banded (after hatching year) there on June 7 (sexes unknown) and on June 17, 1970 (male). Gabrielson and Jewett

(1940) cite two summer specimens of Black-throated Sparrow from Harney County and Brown (1960) observed the species on several dates in May and June at Nilakishi Ridge (Klamath County) and state that one bird appeared to be gathering nesting material on June 3, 1959. Dubois (1959) saw one near Beaverton and two near Milwaukie (northwestern Oregon) in May and one at Depoe Bay (Lincoln County) on June 4–6, 1959. A bird was observed in Curry County (Brookings ?) on May 23, 1970 (*Aud. Field Notes* 1970:638). An adult male of the species was collected on a farm near Lebanon (Linn County) on May 3, 1970 (Scott *et al.* 1972).

Junco hyemalis. Dark-eyed Junco.

Specimens: Numerous specimens from Prospect area, Medford and Ashland, both sexes, all months. The Dark-eyed Junco is common breeding bird in the Mixed Conifer Forest of the county It winters in the low elevations of the Mixed Conifer Forest an Chaparral-Oak Community, arrives in Bear Creek Valley in lat October, and departs by April.

Spizella arborea. Tree Sparrow.

A Tree Sparrow was reported at Ashland on January 30, 1965 Other records of this species from western Oregon are three bird seen in the southern Willamette Valley in winter and spring (Gullio 1951) and one that was banded and photographed near Corvalli (Benton County on November 18, 1962; Strauch 1963). Gabrielso and Jewett (1940) list the species as an irregular winter resident i Oregon occurring from October through March.

Spizella passerina. Chipping Sparrow.

Specimen: Prospect, male, May 8, 1934. The Chipping Sparrow is common migrant and breeding species. It breeds throughout most the Mixed Conifer Forest in mountain meadows and open ponderos pine from 610 m to near timberline. Earliest, February 20, Ashlan latest, October 7, Medford.

Spizella atrogularis. Black-chinned Sparrow.

Accidental. Two birds were discovered on the chaparral covere slope of Roxy Ann Peak on June 7, 1970. A female (after hatchin year) was banded there on June 18 and three others were observe on July 2, 1970. A singing male was seen at the same location fro May to July 10, 1971. Gabrielson and Jewett (1940) do not list th species.

Zonotrichia querula. Harris' Sparrow.

Specimen: Ashland, male, May 10, 1962. This species is a ra visitor to Jackson County. Two additional specimens taken ne Medford on February 1–2, 1912, are reported in Gabrielson and Jewe (1940). There are several sight records of individual birds at a feed t Central Point (Richardson and Sturges 1964). The Harris' Sparrow ay occur almost annually during winter in small numbers, especially t feeders, and has been reported at Ashland and Phoenix in April.

Zonotrichia leucophrys. White-crowned Sparrow.

Specimens: Two, 12.9 km SW Prospect, male and sex ?, April 16, 947, and September 14, 1951; 3.2 km N Prospect, male, April 19, 934; Ashland, male, April 25, 1965. This sparrow is a very common inter resident in the Lower Rogue River and Bear Creek valleys and oothills. Earliest, September 14, Prospect; latest, April 25, Ashland.

Zonotrichia atricapilla. Golden-crowned Sparrow.

Specimens: Five, Ashland, both sexes, October, February, April; rospect, sex?, October 8, 1961. This species is a very common winter esident in the Lower Rogue River and Bear Creek valleys and oothills. Earliest, September 8, Medford; latest, May 15, Medford.

Zonotrichia albicollis. White-throated Sparrow.

Specimens: Two, 12.9 km SW Prospect, male, September 18, 1951, nd male, May 2, 1953. The White-throated Sparrow is an uncommon igrant and winter resident in the Lower Rogue River and Bear reek valleys. It is most often observed during winter when it may ccasionally visit feeders with other species in the genus *Zonotrichia.* he species has been reported at Ashland, Talent, Phoenix, and edford.

Passerella iliaca. Fox Sparrow.

Specimens: Two, SW Prospect, female, May 2, 1953, female and ex?, November 26, 1945. The Fox Sparrow is a fairly common winter esident in the Lower Rogue River and Bear Creek valleys and foot-ills and is a fairly common breeding species in the high Cascades. abrielson and Jewett (1940) consider the species a breeding bird both the Cascade and Siskiyou mountains.

Melospiza lincolnii. Lincoln's Sparrow.

Specimens: 12.9 km SW Prospect, sex?, September 26, 1949; Ashland, ale, April 26, 1965. Gabrielson and Jewett (1940) list a specimen aken at Medford on April 23 (year not given), and one taken at shland on May 6, 1914. The Lincoln's Sparrow is an uncommon ummer resident in the Cascade Mountains that probably breeds at oward Prairie. It is a fairly common winter resident and migrant in ear Creek Valley and at White City.

Melospiza georgiana. Swamp Sparrow.

Accidental. A Swamp Sparrow was observed singing near Shady ove on April 5, 1969. The species was reported at Eugene (Lane ounty) on December 29, 1968 (*Aud. Field Notes* 1969: 513). A female f this species collected at Tillamook (Tillamook County) on Novem-er 29, 1955 (Burleigh 1957) is the first Oregon specimen.

Melospiza melodia. Song Sparrow.

Specimens: Five, 12.9 km SW Prospect, both sexes, December, January, February; Medford, male, October 18, 1969; Ashland, male, May 4, 1969. The Song Sparrow is a common permanent resident in the Mixed Conifer Forest of some foothill stream valleys and slightly more common along streams and marshes in the Lower Rogue River and Bear Creek valleys.

Calcarius lapponicus. Lapland Longspur.

Accidental. Nine birds were observed at Agate Reservoir on January 26 to February 1, 1971, by several persons.

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THE SCREECH OWL: ITS LIFE HISTORY AND POPULATION ECOLOGY IN NORTHERN OHIO

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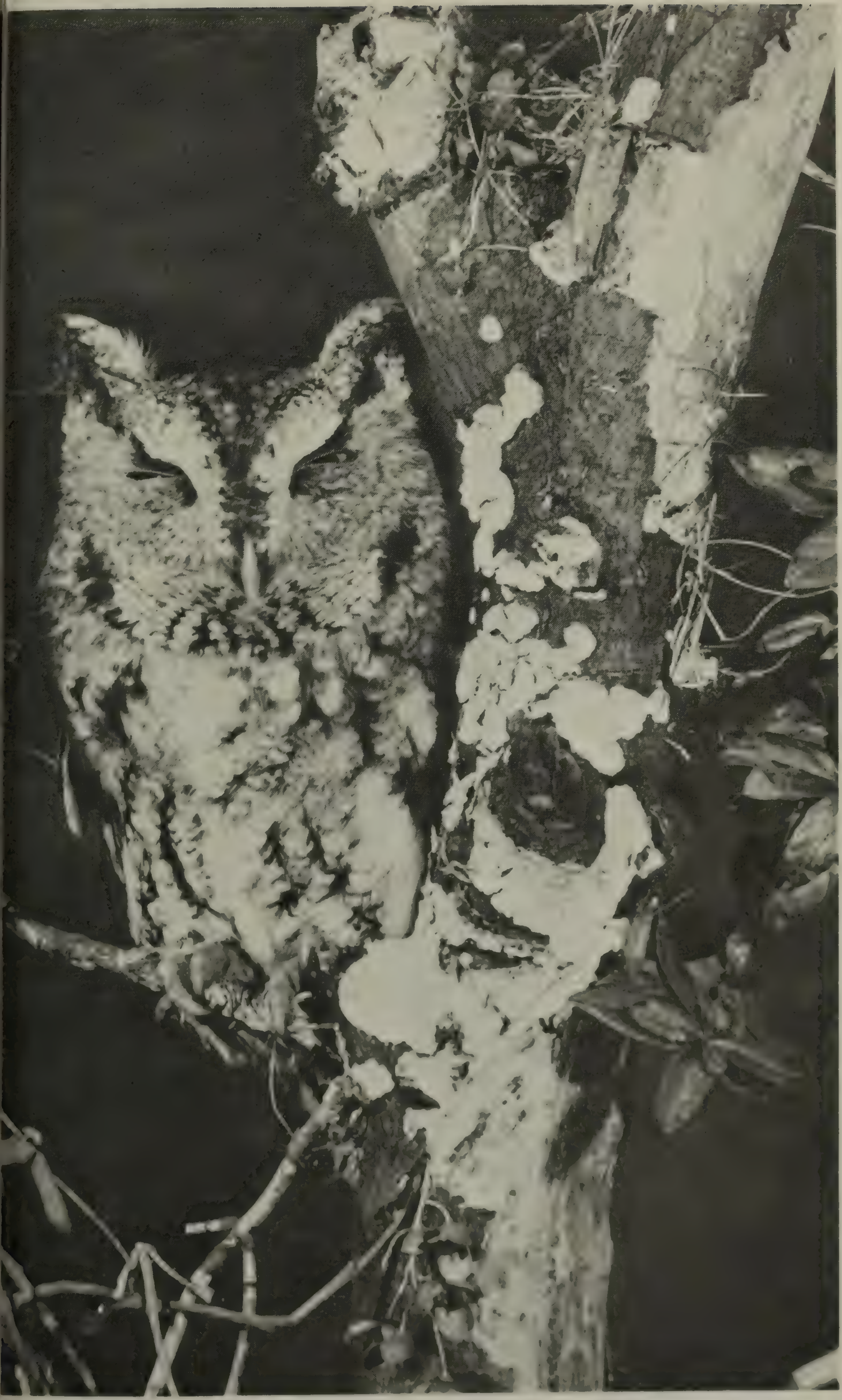

Frontispiece—The cryptic coloration of the gray phase of the screech owl (*photo courtesy of G. Ronald Austing*).

INTRODUCTION

The screech owl (*Otus asio*) is native to North America and breeds throughout the United States and in portions of Canada and Mexico. It is a small owl, 20 cm (8 in) in length from the tip of the bill to the tip of the tail, with a wing span of 56 cm (22 in); it has yellow eyes and prominent ear tufts (see Frontispiece). Although the species is common throughout much of North America, it has not been studied intensively, particularly over a long period. The published literature is concerned mostly with food habits, color phase, taxonomy, and miscellaneous observations. Breeding biology and population dynamics have received little attention.

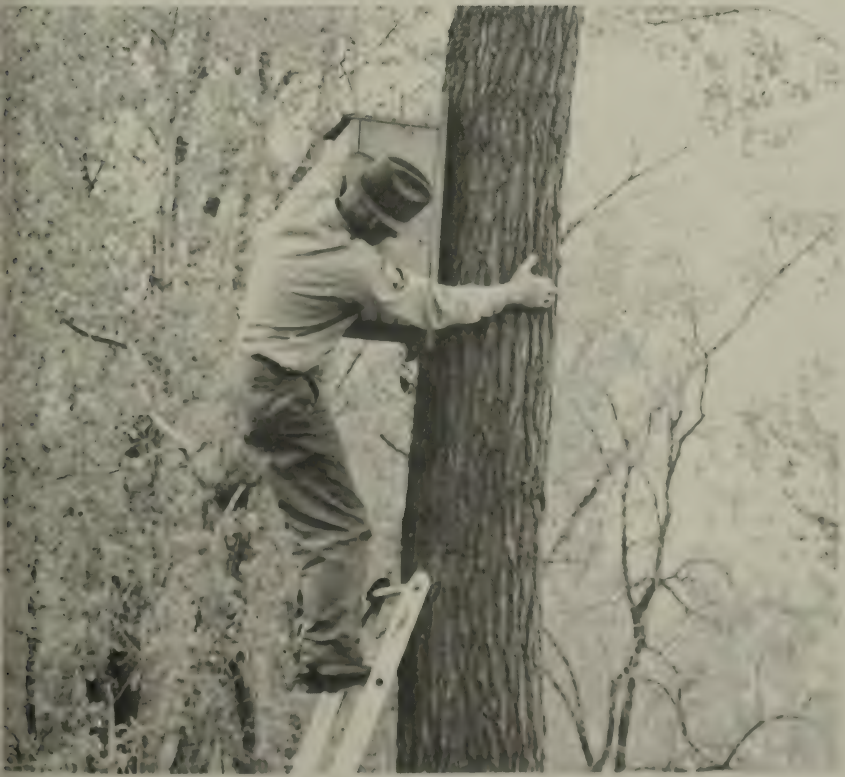

Fig. 1.—A nest box is checked on the study area (*photo courtesy of George Laycock*).

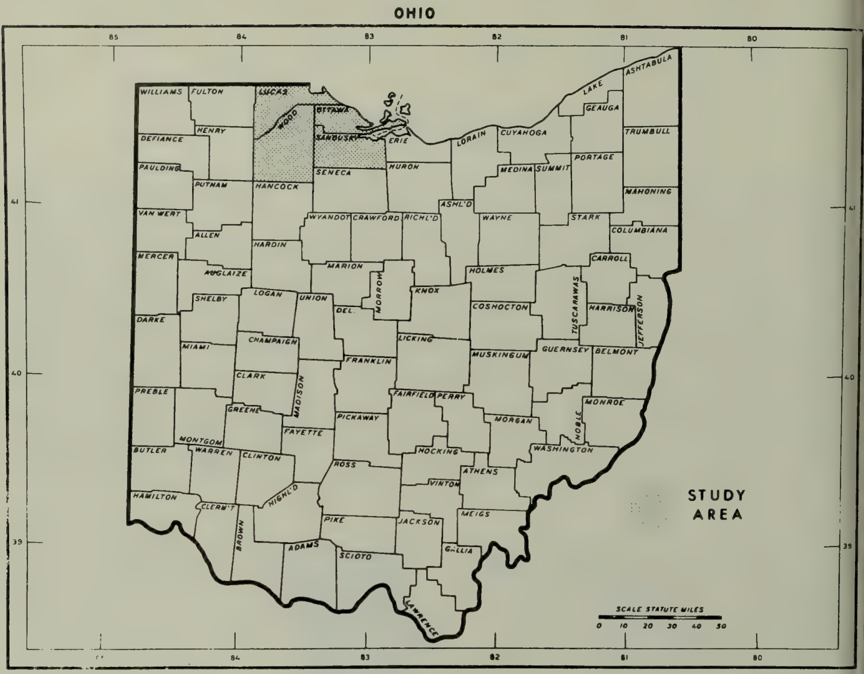

Fig. 2.—The four-county study area in northern Ohio.

This report presents the basic life history and populatio information about screech owls in northern Ohio over a 30-y period. The owls studied were nesting in boxes (Fig. 1) establishe for wood ducks (*Aix sponsa*) along rivers, creeks, and marshes in four-county area (Ottawa, Sandusky, Wood, and Lucas Counties near Lake Erie (Fig. 2). No special trapping techniques wer required as the screech owls readily used these nesting boxes an could be easily captured while in them. More than 3,000 owls wer captured and banded; 500 were recaptured after the initial banding some 10 or 15 times. This process provided a large quanity of basi information for this report.

The banding data provided useful information on dispersa mortality, and age at sexual maturity; in several instance however, the data were supplemented by banding data of othe workers in the area north and east of Missouri. More than 50 nesting attempts by the screech owls were recorded, and 5 different species of birds were listed as food items in the nest boxe during the nesting season. Supplemental information on th seasonal food habits of the screech owl was obtained from food habit cards filed at the Patuxent Wildlife Research Center, Laurel, Maryland.

The senior author initiated the study in 1944 and collected the field data through 1973. The junior author analyzed the data, wrote the report and coordinated the pesticide phase of the study with the Patuxent Wildlife Research Center in 1973. We have also brought together the relevant literature on the screech owl with emphasis on population ecology. This subject may be particularly timely since McLane and Hall (1972) showed that a low dietary dosage of DDE (a chlorinated hydrocarbon pesticide) causes eggshell thinning under laboratory conditions. Eggshell thinning has been associated with declines of many raptorial and fish-eating birds in both western Europe and North America (Ratcliffe 1967; Hickey and Anderson 1968; Lockie et al. 1969; Hickey 1969). Furthermore, the screech owl data have been subjected to a modeling process (Henny et al. 1970) to determine population parameters for the species in northern Ohio.

The Study Population

The screech owl population reported herein is one that nested in wood duck boxes in northern Ohio between 1944 and 1973. The fact that the birds were using artificial nesting structures may cause a bias in a portion of the findings, particularly in terms of population trends (indices) and annual recruitment rates. For example, trends in population numbers should not be based on the percentage of the nest boxes occupied each year because the nest boxes were always placed in suitable habitat. A population reduction from the loss of habitat would be undetected by such an approach. Our population index most likely represents the annual population nesting in suitable habitat. We believe, however, that most of the other findings presented in this paper are representative of the wild screech owl population in the study area, and, as such, were not biased by the type of nest site used.

Screech owls began using the nest boxes in northern Ohio much earlier than wood ducks. In fact, we have found wood ducks nesting in boxes after young screech owls have fledged. It is our subjective assessment that screech owls keep starlings (*Sturnus vulgaris*), which are much more competitive than the owls, out of the nest boxes within the owls' feeding areas. Upon occasion, starlings will bury wood duck eggs under their nesting material and cause the hen to desert. We therefore contend that wood duck nesting success is enhanced by the presence of screech owl nesting. Adequate numbers of nest boxes should be provided for both species.

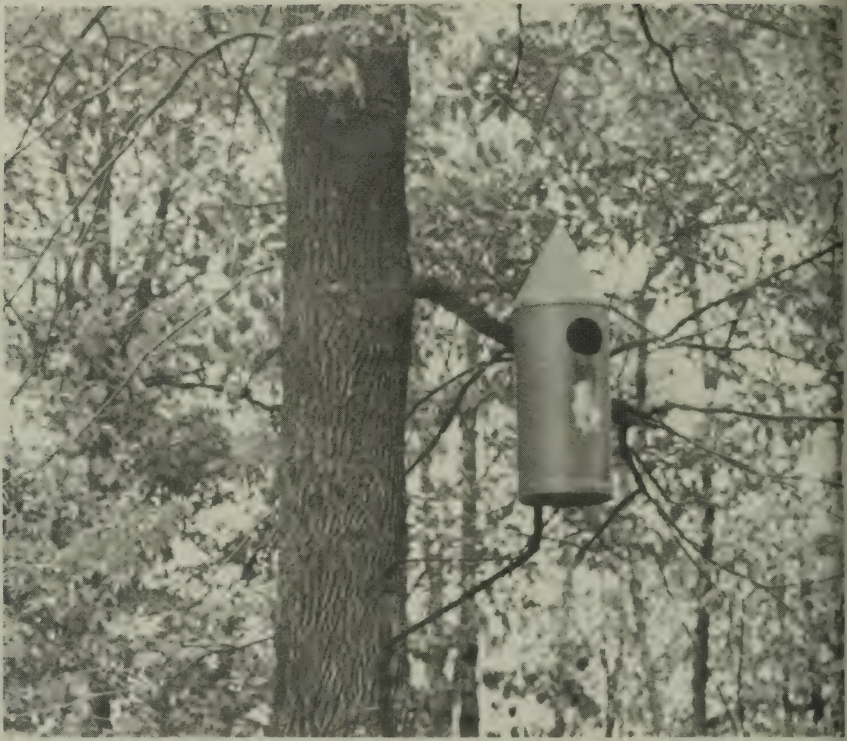

Fig. 3.—An improved nest box which was used on the study area since the early 1960's. One hundred of this type of box were available annually during the last decade.

Beginning early in the 1960's, most of the nest boxes were made with cylinders shaped like rockets (after the design of Bellrose 1955; Fig. 3). The owls used the boxes for nesting, roosting, and feeding.

The Study Area

Nearly all of the study area lies within the boundaries of what was called the "Black Swamp" during the early annals of North American history. The Black Swamp was drained late in the nineteenth century and is so transformed that an observer would have difficulty in estimating its former extent. Mayfield (1962) discussed changes in the natural history of the area since the coming of the white man, but indicated that agriculture had modified this region long before a competent naturalist had studied the plants and animals.

From the beginning of settlement in the Black Swamp (circa 1820), the entire agricultural system revolved around corn. Most of the conversion to agricultural land in northwestern Ohio took place after 1850 and continued until the turn of the century (Kaatz 1953). Within a few decades, the Swamp was transformed into one of the most productive agricultural regions in Ohio. By 1930, the Black Swamp was the most completely cropped area in the State (Sitterley and Falconer 1933). Today, like 60 or 70 yr ago, the Black Swamp lands are dominantly rural. Although there are urban and industrial areas around Toledo and other smaller cities, the rural scene prevails elsewhere.

The Black Swamp, like most dense, unbroken forests, was not rich in wildlife (Kaatz 1953). Information on bird populations is scarce; however, it is almost certain that many of the species common at the time of settlement have been extirpated or greatly reduced in numbers. Conversely, some of the most common birds today were rare or nonexistant in the area when the first settlers arrived. Some species that are abundant today prefer nesting sites provided by the structures of modern man and are scarcely to be found in natural sites. Mayfield (1962) reviews the changed status of a number of bird species. It is unclear how or to what extent habitat changes have influenced the status of screech owls. In reference to central Ohio, Trautman (1940:275–276) reported, "Statements by hunters and farmers who were well acquainted with the screech owl indicate that before 1900 this species was decidedly uncommon in the area and that with the removal of most of the forests and the decrease in numbers, or extirpation, of barred and horned owls, the screech owl became increasingly numerous. These statements agree with my studies." Furthermore, Bent (1938:246) states, "The screech owl also has been known to nest frequently, even regularly, in cavities in trees close to houses in towns and cities, thus showing more confidence in human beings than most other owls show."

An illustration of an open field adjacent to a wooded creek bottom where several screech owls nested annually is shown in Fig. 4. The loss of forested land in the four-county study area—12% between 1958 and 1967 (Table 1)—is continuing. Farmers are using more and more of their land each year for agriculture. The wooded creek bottom and woodlots are being cleared for mechanized agriculture. Only 7.6% of the study area was classified as forested land in 1967. This contrasts with about 90% of the area being forested in 1853 (Diller 1962). In 1967, the four-county area consisted of 85.2% cropland, 1.9% pasture, 7.6% forested, and 5.3% other land (Anon. 1971). The most important agricultural crops are corn and soybeans.

Fig. 4.—A typical open field adjacent to a wooded creek bottom in the study area.

Table 1. *The forest area in the four-county study area in northern Ohio, 1958 vs. 1967 (from Anonymous 1971).*

	Forest area (acres)	
County	**1958**	**1967**
Lucas	—[a]	23,873 (19.5)[b]
Ottawa	7,485	8,398 (5.9)
Sandusky	21,000	15,932 (6.6)
Wood	19,217	17,616 (4.9)
Total[a]	47,702	41,946

[a] The 1958 Lucas County figure was calculated with an incorrect standard (H. G. Smith, Soil Conservation Service, Columbus, Ohio, personal communication); therefore, the totals are for the three-county area with comparable data.

[b] In parentheses percent of county inventoried which was forested.

Accumulation of Data

A measure of the annual and seasonal effort to conduct this study is of importance. Unfortunately, the person-days spent in the field were not recorded. The number of nest boxes checked during the nesting season provides an index of annual effort during the 30-yr study. This measure is admittedly crude because the number of visits to each nest box was not recorded. For example, some of the boxes could not be visited more than once during several of the years (for additional details see results). Forty-five boxes were checked in 1944, the first year of the study. The average number of nest boxes checked for each 5-yr period during the study was as follows: 479, 727+, 985+, 730, 650, 678. The exact number of nest boxes checked from 1952 to 1955 is unknown; however, a high percentage of the boxes were checked only once at the time young were about to fledge. From 1956 to 1973, the annual effort was consistent. More than 4,249 boxes were checked during the 30-yr period.

Breeding Season

Pairs appeared in the nest boxes by the first week of February. During the initial years of the study, some nest desertions resulted from visiting the boxes in February and March. Therefore, in later years the nest boxes were not checked before mid-April. Most screech owls were incubating by mid-April, and, unless the incubating birds were handled, the nests were not deserted. Nest boxes were checked at this time and the males banded if they were in the nest box. Females were not handled until the young hatched. The nest boxes were generally checked three times between mid-April and early June. The females were banded during the first check in which young were in the nests. The young were not banded until the color phase could be determined.

Postfledging Period

Nest boxes were little used after the young fledged, but use began to increase in October when the deciduous trees lost their leaves. We visited nest boxes only rarely in late summer or early fall.

Winter Period

November, December, and January was a period of much nest box use by individual birds. The wood duck boxes were checked periodically during these months and a large number of screech owls was banded. Beginning in the early 1960's all boxes were visited during the annual maintenance check in January; not all boxes were visited during the winter in the earlier years.

In addition to roosting, the screech owls used the boxes for feeding stations during winter. The trait of carrying prey to a cavity before feeding may have evolved: (1) to lower screech owl vulnerability to predation by larger owls, (2) to prevent other animals from eating the prey not consumed immediately by the owls, (3) as a food storage technique to carry the owls over periods of inclement weather or periods of low food availability, or (4) from the habit of the male feeding the female (Burton 1973). This food-carrying trait accounts for the large number of prey items recorded in the nest boxes. As mentioned above, the owls did not use the nest boxes in late summer or early fall when the leaves of deciduous trees are present. We believe the dense foliage protected the screech owl from predation by larger owls during this period. Thus, the need for using a cavity as a feeding station was minimized in the late summer and early fall.

TAXONOMY

The screech owl is confined to North America and has a continuous breeding distribution from southeastern Alaska, southern British Columbia, southern Manitoba, southern Ontario, southern Quebec, and Maine south to the Cape district of Baja California, Jalisco, Hidalgo, southern Tamaulipas, and Florida (American Ornithologists' Union 1957). The American Ornithologists' Union also recognizes the whiskered owl (*O. trichopsis*) in the mountain areas from southeastern Arizona to Honduras and the flammulated owl (*O. flammeolus*) in southern British Columbia south through the mountains west of the Great Plains to the highlands of Mexico and Guatemala. Additionally, 18 subspecies of the nonmigratory screech owl are recognized.

Numerous other classifications were in effect before 1957 and agreement among taxonomists is still not complete. As with most species of birds, subspecies of the screech owl have been described on the basis of variation in the length of the wing, bill, tail, and tarsus; and in the color pattern of the plumage. In addition to geographical variation, the species is polymorphic in the eastern part of its range and has two distinct color forms: one with the plumage mainly bright rufous and the other with plumage mainly gray. An intermediate color phase also exists, but in low frequency. Elsewhere in the range, only gray birds occur. Owen (1963a) concluded that most of the subspecies had been separated by drawing arbitrary lines through clinal variations. He further indicated that new subspecies were still (in 1959) being described, sometimes based upon as few as five specimens, and thought that the situation should be remedied. Until such time as reproductively isolated sympatric populations are discovered in any part of the range, Owen believed that no subspecies should be recognized and the AOU Check-list entry should include geographical variation.

Marshall (1967), on the other hand, stated that taxonomists have been so engrossed with subspecies that they have ignored a species problem existing in north and middle America. He proposed that seven species and four incipient species of *Otus* occupy north and middle America, where they overlap without interbreeding, in such combinations as their distributions and habitats permit. Marshall's conclusion were based on both morphology and song patterns. The Committee on Classification and Nomenclature of the American Ornithologists' Union has not commented on the screech owl since the 1957 Check-list was published. For the purposes of the present paper, no trinomial is used and the screech owl population is described on the basis of geography, i.e., the nonmigratory population resident in northern Ohio.

FOOD HABITS

The screech owl is one of the most nocturnal of North American owls. Allen (1924) made a series of observations on the feeding of a brood of young and concluded that the earliest time at which feeding began was 2025, and the latest was 2112; the earliest time at which feeding ceased was 0250, and the latest was 0415. He further reported that both parent birds were engaged in caring for the young. These nighttime hunts yielded a variety of food items including many passerine birds that were apparently captured on their roosting sites.

The food habits of most birds of prey were first studied in detail during the latter part of the 19th and early 20th centuries. Notable publications of this era were by Fisher (1893) and Errington (1932). In summary, they reported that the screech owl diet consisted of mice, shrews, rats, other mammals, small birds, lizards, amphibians, fish, crayfish, insects, spiders, and other invertebrates. Bent (1938) indicated that although birds do not form as large a portion of the food as mammals, the list of species is a long one. More recently, James and Martin (1950) and Stewart (1969) have added several species of birds to the list.

McDowell and Luttringer (1948) estimated that the diet (percentage occurrence) of the screech owl consisted of 22.75% mice, 18% other mammals, 18% songbirds, with the remaining 41.25% reptiles, amphibians, fish, and insects, and other invertebrates. An analysis of 419 pellets collected in western Missouri from 1957 to 1967 showed a preponderance of small rodents in screech owl diets (Korschgen and Stuart 1972). Mice and rats together made up 87% of all foods. Songbirds amounted to 8.4% in occurrence and only 4.1% of the volume. Among birds in portions of the southwestern United States and western Mexico, Ross (1969) lists the common screech owl as being both carnivorous and insectivorous, the whiskered screech owl as being primarily insectivorous but on occasion supplementing its diet through carnivorous predation, and the flammulated screech owl, as being entirely insectivorous. Errington (1932) indicated that as a rule screech owls ate what was most convenient to catch and of a size easy to handle. He further noted that their preferred prey seemed to be mice if such were available, but in the event of a mouse shortage they readily turned to birds. These studies suggest that the screech owl is an opportunistic predator whose diet includes nearly every class of animal life.

During the Nesting Season

Allen (1924) intensively studied a pair of nesting screech owls in New York for 45 days and found that birds represented an important portion of the diet. Allen provided a list of 77 birds of 18 species brought to the young during the 45-day period. He concluded that because the feathers in the nest undoubtedly represent many more than one bird of each species, the grand total of birds required to feed the three young owls from the time of hatching until left by the old birds were certainly more than 100. Recently, Stewart (1969) also indicated that food items found at the nests of screech owls in Ohio and North Carolina consisted primarily of birds. However, Sherman (1911) reported 40 food items during the nesting season (apparently in Iowa), which included 3 frogs, 1 shrew, 28 mice, and only 8 birds.

During our nesting studies, 477 food items were recorded at wood duck nest boxes used by screech owls. Our observations were made between 26 March and 7 June, and nearly all food items found were intact. Most of the food was stored in the nests during the first 2 wk after the young hatched (late April and early May). Fifty-three species of birds were recorded, making up 64.8% of the items found during the nesting season (Table 2). An attempt was made to calculate biomass of the prey; however, sufficient information was not available regarding the age classes for several of the birds, mammals, and fishes which vary greatly in size. Preliminary calculations suggested that the percentage occurrence and percent biomass in the diet (with the exception of invertebrates which were probably eaten immediately and not adequately represented in the sample) were similar.

Of the five most common species of birds found in the nests, three are transients (Campbell 1968): the yellow-rumped warbler (average arrival 19 April, average departure 20 May), white-throated sparrow (average arrival 14 April, average departure 22 May), and the ruby-crowned kinglet (average arrival 11 April, average departure 17 May); one was a permanent resident (the house sparrow); and one was primarily a summer resident (the starling) nesting in northern Ohio in May. Furthermore, 49 of the 53 species of birds found in the diet of the screech owl must be considered migratory. Therefore, the screech owl definitely takes advantage of the spring migration of small birds to feed its young

Table 2. *Species stored as food by screech owls during the nesting season in northern Ohio*[a].

Family	Species	n
Birds		
Columbidae		
	Mourning Dove (*Zenaida macroura*)	2
Cuculidae		
	Yellow-billed Cuckoo (*Coccyzus americanus*)	1
Strigidae		
	Screech Owl (*Otus asio*)	1
Picidae		
	Common Flicker (*Colaptes auratus*)	1
	Downy Woodpecker (*Dendrocopos pubescens*)	1
Tyrannidae		
	Eastern Kingbird (*Tyrannus tyrannus*)	1
	Unidentified Flycatcher	1
Hirundinidae		
	Purple Martin (*Progne subis*)	4
	Barn Swallow (*Hirundo rustica*)	4
	Tree Swallow (*Iridoprocne bicolor*)	2
	Bank Swallow (*Riparia riparia*)	1
	Cliff Swallow (*Petrochelidon pyrrhonota*)	1
Corvidae		
	Blue Jay (*Cyanocitta cristiata*)	4
Certhiidae		
	Brown Creeper (*Certhia familiaris*)	1
Troglodytidae		
	Winter Wren (*Troglodytes troglodytes*)	1
Mimidae		
	Gray Catbird (*Dumetella carolinensis*)	5
	Brown Thrasher (*Toxostoma rufum*)	3
Turdidae		
	American Robin (*Turdus migratorius*)	10
	Hermit Thrush (*Catharus guttatus*)	8
	Swainson's Thrush (*Catharus ustulatus*)	7
	Wood Thrush (*Hylocichla mustelina*)	2
	Veery (*Catharus fuscescens*)	2
	Unidentified Thrush	3
Sylviidae		
	Ruby-crowned Kinglet (*Regulus calendula*)	18
	Blue-gray Gnatcatcher (*Polioptila caerulea*)	4
	Golden-crowned Kinglet (*Regulus satrapa*)	2
	Unidentified Kinglet	1
Sturnidae		
	Starling (*Sturnus vulgaris*)	19
Parulidae		
	Yellow-rumped Warbler (*Dendroica coronata*)	40
	Palm Warbler (*Dendroica palmarum*)	5
	Common Yellowthroat (*Geothlypis trichas*)	3

(Cont'd)

Table 2 (Cont'd)

Cape May Warbler (*Dendroica tigrina*)	2	
Black-and-white Warbler (*Mniotilta varia*)	1	
Chestnut-sided Warbler (*Dendroica pensylvanica*)	1	
Tennessee Warbler (*Verminvora peregrina*)	1	
Yellow Warbler (*Dendroica petechia*)		
Nashville Warbler (*Vermivora ruficapilla*)	1	
Canada Warbler (*Wilsonia canadensis*)	1	
Unidentified Warbler	6	
Ploceidae		
House Sparrow (*Passer domesticus*)	25	
Icteridae		
Red-winged Blackbird (*Agelaius phoeniceus*)	5	
Common Grackle (*Quiscalus quiscula*)	5	
Brown-headed Cowbird (*Molothrus ater*)	1	
Thraupidae		
Scarlet Tanager (*Piranga olivacea*)	1	
Fringillidae		
White-throated Sparrow (*Zonotrichia albicollis*)	37	
Song Sparrow (*Melospiza melodia*)	14	
Cardinal (*Cardinalis cardinalis*)	7	
American Goldfinch (*Spinus tristis*)	4	
Dark-eyed Junco (*Junco hyemalis*)	4	
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	3	
Chipping Sparrow (*Spizella passerina*)	2	
Field Sparrow (*Spizella pusilla*)	2	
Savannah Sparrow (*Passerculus sandwichensis*)	2	
Tree Sparrow (*Spizella arborea*)	1	
Vesper Sparrow (*Pooecetes gramineus*)	1	
Indigo Bunting (*Passerina cyanea*)	1	
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	1	
Unidentified Sparrow	4	
Unidentified Family		
Small Bird	16	
Large Bird	1	
Subtotal (percent occurrence)		309 (64.8%)
Mammals		
Soricidae		
Unidentified Shrew	4	
Chiroptera (Unknown Family)		
Unidentified Bat	2	
Sciuridae		
Gray Chipmonk (*Tamias striatus*)	1	
Cricetidae		
Deer Mouse (*Peromyscus* sp.)	37	
Meadow Vole (*Microtus* sp.)	52	
Unidentified Mouse	3	
Muridae		
Norway Rat [young] (*Rattus norvegicus*)	6	
House Mouse (*Mus musculus*)	39	

(Cont'd)

Table 2 (Cont'd)

Leporidae		
Eastern Cottontail [leg] (*Sylvilagus floridanus*)	1	
Subtotal (percent occurrence)		145 (30.4%)
Amphibians		
Ranidae		
Leopard Frog (*Rana pipiens*)	5	
Subtotal (percent occurrence)		5 (1.0%)
Fish		
Centrarchidae		
Green Sunfish (*Lepomis cyanellus*)	5	
Clupeidae		
Gizzard shad (*Dorosoma cepedianum*)	8	
Cyprinidae		
Unidentified Minnow	1	
Subtotal (percent occurrence)		14 (2.9%)
Invertebrates		
Crayfish (*Cambarus* sp.)	2	
Leech (*Hirudinea*)	2	
Subtotal (percent occurrence)		4 (0.8%)
Grand Total		477 (99.9%)

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[a] Smaller food items were probably eaten immediately rather than being stored in the nest boxes and were undetected.

A nest box containing four young screech owls at the Winous Point Shooting Club had 40 dead birds stored on 5 May 1972. These included 24 yellow-rumped warblers, 3 common yellowthroats, 1 palm warbler, 2 white-throated sparrows, 1 Nashville warbler, 4 blue-gray gnatchatchers, and 5 unidentified birds—2 of which were sparrows but not house sparrows. When the nest was revisited on 22 May 1972 to band the four young, no food was left in the box. Young flightless starlings were also taken from their nests on several occasions. Three young starlings and one adult were found in a nest box on 14 May 1955. Several trips were apparently made by the screech owl to the starling nest to fill its coffers.

In Autumn and Winter

Data collected by Wilson (1938) at Ann Arbor, Michigan, primarily in the autumn and winter, showed a preponderance of mammals in the screech owl diet. Only four skulls of birds (0.3% frequency) were found in 1,408 pellets containing 1,549 skulls. Animals which were identified included: meadow mice (87%); deer mice (5%); Cooper lemming mice, *Synaptomys cooperii* (3%); short-tailed shrews, *Blarina brevicauda* (3%); the remainder (2%) included jumping mice, *Zapus hudsonius*; least shrews, *Cryptotis parva*; red squirrels, *Sciurus hudsonicus*; eastern moles, *Scalopus aquaticus*; Norway rats, birds, parts of crayfish, and insects. Wilson concluded by saying that the screech owl's diet showed a definite cycle. During the spring many owls fed upon insects and amphibians. Elsewhere in his paper Wilson (1938:193) notes, "The tendency for owls in this vicinity to ignore birds can possibly be explained by the abundance of mice . . . ." Similar results were reported from Michigan in a more recent study by Craighead and Craighead (1956) who reported that meadow mice and deer mice made up 95.3% of the diet in 1942 and 87.2% in 1948. The percentage of small birds (1.2 and 11.4%) showed a substantial increase in the latter winter. According to the Craigheads, this trend toward more small birds in the diet reflected the change in the relation of meadow mice to small bird densities of the latter year.

Fall and winter food items found in the nest boxes during our study totaled 121. The information was collected between 15 October and 23 February, with the majority being recorded in December. We estimated that the screech owl diet during the fall and winter in northern Ohio consisted of approximately 60.3% mammals, 26.4% birds, 5.8% fish, 5.0% frogs, and 2.5% crayfish (Table 3). The nonmigratory house sparrow and cardinal formed over half of the avian food items whereas the migratory bird species were most important during the nesting season.

An observation made in January 1971 was of special note. A screech owl's talons had pierced the skull of a blue jay, but both birds were found dead entangled in a hawthorne tree (*Crataegus* sp.). A defective eye was noted in 13 owls captured during the study. Generally, the defective eyes were sealed shut. The defective eyes may have resulted from owls trying to capture prey in heavily wooded areas; however, the incidence of eye injuries was low (only 13 in more than 3,000 birds handled).

able 3. *Food items found at nest boxes occupied by screech owls in the fall and inter in northern Ohio*[a].

Birds		Mammals		Fish		Amphibians and crayfish	
ouse sparrow	9	Meadow mouse	28	Gizzard shad	5	Leopard frog	6
ardinal	8	Deer mouse	20	Bullhead	1	Crayfish	3
ourning dove	4	House mouse	10	Unidentified fish	1		
lue jay	3	Norway rat	9				
ree sparrow	2	Shrew	5				
tarling	1	Unidentified mouse	1				
ommon redpoll	1						
creech owl	1						
ermit thrush	1						
merican robin	1						
ommon flicker	1						
otal items	32		73		7		9
ercent (occurrence)	26.4		60.3		5.8		7.5

A few of the food items may have been taken earlier in the year.

ish in the Diet

During the 1973 nesting season, a nest box on our study area was ound with several dozen gizzard shad. Five green sunfish were lso noted in a nest on 5 May 1972 and one minnow on 3 May 1973. everal other nest boxes smelled of fish when they were visited, lthough no fish were present.

The presence of fish in the diet made us curious about 10 band ecovery letters of screech owls that were reported to the Bird anding Laboratory as drowned. It is doubtful that fishing ctivities by the owls led to their deaths. Six were found in water anks (specifically, two in horse troughs and one in a windmill ank), two in rain barrels, one in a backyard swimming pool, and no etails were given on the remaining recovery. Although it might be uspected that the drowned birds were all young and inexperienc-d, only three were less than 2 mo old, whereas all of the others were ore than 1 yr old. Kelso (1944) has included water as one of the hief considerations in the choice of territory, along with suitable oosting and nesting cavities, and the absence of larger species of owls. Kelso indicated that screech owls will drink every day and bathe every 3 or 4 days if water is available. The birds that drowned may have been attempting to bathe or drink, or, more likely, attempting to catch insects or rodents in or near the water. Records of fishing appear in the literature (e.g., Treat 1889), and live fish have been found in tree cavities utilized by screech owls (Frazar 1877).

An incident in our study area on 8 December 1946, provides additional information concerning the relationship of screech owls to water. An oil slick was noticed on the Portage River and three screech owls from the area were captured that day with their legs and underparts covered with oil. The oil on one owl was still present on 14 January 1947 but it had been removed by 27 April 1947. We believe that if the owls were bathing in the water, oil would have been found throughout their plumage. These data lend support to the contention that screech owls take live prey from streams and ponds, and that aquatic food items found in nest boxes were no merely carcasses found along the shoreline. Based on our data, we cannot answer the question, "Do all screech owls take fish occasionally or do a few birds specialize in fish?"

Seasonal Variation

A seasonal pattern in the food habits of the screech owl became apparent during this study, although our sampling method was biased, i.e., most of the invertebrates taken by the screech owls were probably undetected in our study. Actually, the mammals and birds exchanged places of importance between the nesting season and the fall and winter (Table 4). Furthermore, the important bird species in the diet were nearly all migratory (Table 2) and no available during the other portions of the year.

Table 4. *The relative importance of birds to mammals in the seasonal diet of th screech owl (data obtained from nest boxes).*

Time collected	No. mammals	No. birds	Percent birds[a]
Nesting season	145	309	68
Fall and winter	73	32	30

[a] The aggregate of birds plus mammals.

Only rarely have authors discussed the food habits of the screech owl during all seasons of the year, although Baird et al. (187:57 stated, "The food is chiefly small quadrupeds, insects, and occasionally, when they have young, small birds." Fisher (1893 presented tabular data on mammals, birds, and other items found n the stomachs of birds collected during various months of the year, but did not analyze the data quantitatively for seasonal variation. Fisher (1893:166), however, did state, "It must be said that occasionally it is destructive to small birds, especially during the breeding season, when it has a number of hungry mouths to fill, and also in suburban districts where its favorite food is hard to procure." Fisher's data were collected primarily in the eastern United States. A reanalysis of his bird and mammal data suggested findings similar to ours reported in Table 4.

The 479 food habit cards (approximately one-half of which were used by Fisher [1893]) filed at the Patuxent Wildlife Research Center, Laurel, Maryland, were reanalyzed for seasonal trends in the screech owl diet (Tables 5 and 6). Only data based on stomach contents were considered, and small sample sizes in June, July, August, and September made it necessary to pool 2-mo periods. The relative importance of arthropods in the diet throughout the year was evaluated on the basis of presence or absence in each stomach. This eliminated the problem of tremendous fluctuations in numbers present in individual stomachs and the problem of trying to obtain an exact count of the numbers present. The importance of arthropods (primarily insects) peaked in late summer and declined during the winter (Table 5). It must be emphasized that the arthropods were not detected in our study probably because they were eaten immediately instead of stored. The diet pattern followed availability, again indicating that the screech owl is an opportunistic feeder. The relative importance of birds to mammals, based on the food habit cards (Table 6), was nearly identical to that found n our study (Table 4).

Table 5. *The relative importance of arthropods (primarily insects) in the seasonal diet of the screech owl (data obtained from 479 stomach content cards at Patuxent Wildlife Research Center).*

Month collected[a]	Stomachs checked	No. samples with arthropods	Percent with arthropods
January	56	6	11
February	34	9	26
March	38	9	24
April	28	16	57
May	46	34	74
June–July	40	31	78
August–September	23	20	87
October	40	24	60
November	98	42	43
December	76	12	16

[a] Only samples collected in the Northeastern United States and Ontario.

Table 6. *The relative importance of birds to mammals in the seasonal diet of the screech owl (data obtained from 479 stomach content cards at Patuxent Wildlife Research Center).*

Month collected	Stomachs checked	No. mammals	No. birds	Percent birds[a]
January	56	33	15	31
February	34	15	5	25
March	38	21	6	25
April	28	8	11	58
May	46	3	4	57
June–July	40	3	6	67
August–September	23	5	4	44
October	40	21	8	28
November	98	52	17	25
December	76	45	14	24

[a] The aggregate of birds plus mammals. April–September the percentage of birds was 57, whereas the percentage for October–March was 26. Other vertebrates in the stomachs include 7 toads, 7 frogs, 2 lizards, and 3 fish.

The nesting season of the screech owl seems to be timed to take advantage of the spring migration of small birds. Lack (1968) concluded that breeding everywhere is timed in relation to the availability of food for the young. Eleanora's falcon (*Falco eleanorae*) of the bare rocky islands in the Mediterranean is another species whose nesting season is correlated with the migration of small birds (Vaughan 1961). This falcon, however, has young in September or October and feeds on the small birds migrating south at this season of the year.

The food source for screech owls during the nesting season is possibly unique for owls. The species is not dependent upon a local rodent population, but is primarily dependent upon the spring migration of birds moving into its hunting territory from great distances away. A series of migrant species move through the nesting area on slightly different schedules in May and offers the screech owl a predictable prey source during the complete period when young are in the nest.

MIGRATION AND DISPERSAL

The 1957 Check-list of the American Ornithologists' Union states that the screech owl in the northeastern United States is mainly resident, but wanders in winter south to Alabama and

Georgia. Owen (1963a), probably repeating the Check-list, also ndicated that a few birds breeding in the North apparently move south in winter. Evidence of such movement between States, based on banding data, is nonexistent. Most interstate recoveries nvolved 16- to 32-km (10- to 20-mi) movements of birds banded near the State lines, although two definite exceptions were found. One bird was banded in Minnesota and reported 300 km (185 mi) southeast in Iowa and another was banded on our study area in northern Ohio and recovered 235 km (145 mi) northwest in Michigan. Both recoveries were reported during the first year of life from birds banded as nestlings. The first bird was banded on 25 May 1932 and found dead on 20 December 1932, and the latter was banded on 14 May 1957 and found dead on 20 December 1957. Since the two recoveries were in opposite directions, they suggest a dispersal of young rather than migration. Our findings are in agreement with Fisher's (1893:167) statement, "This owl breeds throughout its range, and does not migrate or even wander far during the winter months."

Dispersal Related to Age and Season

Banding data show that young screech owls begin dispersing from their natal area in late summer and early fall (Table 7), and that by about 1 October, only one-fourth of the surviving young remain in the 10′ block (approximately 23,500-hectare area[1]) where they were hatched. Some young disperse more than 160 km (100 mi). In contrast, about three-fourths of the adult birds remain sedentary and stay in the 10′ block where banded (Table 7). In addition, 87% of the adults remained within 16 km (10 mi) of the banding site and no bird moved more than 64 km (40 mi) (Table 8). Furthermore, three of the four birds that moved beyond 32 km (20 mi) were 6 yr old or older; they may have moved the additional distance to obtain a new mate after their original mate died (adult screech owls have a relatively high adult mortality rate). Generally, there is little movement among adult screech owls. Hence, the major means by which a transfer of individuals occurs among populations of the nonmigratory screech owl is dispersal of young birds. The same findings were reported for the nonmigratory song sparrow by Johnston (1956).

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[1] An arbitrary geographical division of longitude and latitude used to report bandings of birds and band recoveries.

Table 7. *A comparison of the seasonal movement of young and adult screech owls banded in northern Ohio and in the remainder of the northeastern United States during the nesting season.*

NESTLINGS (Banded April–June)

Recovery	**Time period of recovery**[b]				
location[a]	**Apr-June**	**July-Sept**	**Oct-Dec**	**Jan-Mar**	**Later years**
0–6 miles	15 (94%)	20 (61%)	4 (24%)	2 (25%)	8 (27%)
More than 6 miles	1 (6%)	13 (39%)	13 (76%)	6 (75%)	22 (73%)
Total	16	33	17	8	30

ADULTS (Banded March–June)

Recovery	**Time period of recovery**[b]				
location[a]	**Apr-June**	**July-Sept**	**Oct-Dec**	**Jan-Mar**	**Later years**
0–6 miles	4 (100%)	4 (80%)	4 (80%)	8 (80%)	23 (74%)
More than 6 miles	0 (0%)	1 (20%)	1 (20%)	2 (20%)	8(26%)
Total	4	5	5	10	31

[a] Recoveries within same 10′ block as banded were considered within 6 miles of the banding site. Owls recaptured by banders were not included.
[b] Months refer to first year after banding.

Dispersal Distance

The mean distance moved by young birds (calculated after 1 October) was 32 km (20 mi), although a majority of the birds were reported to have moved much shorter distances (Table 8). Several authors have attempted to determine if dispersal distance is random. Most of the tests have involved a comparison of the observed frequency distribution with the Poisson distribution (French et al. 1968). If the dispersal distance is random, then the number of animals in successive zones outward from the center should show a Poisson distribution. In evaluating this distribution the only data readily available on the place of banding and the place of recovery were the respective 10′ blocks in which these events occurred. To change areas to locations for which distances can be calculated, we used the geographic centers of the 10′ blocks involved. By using this approximation in Table 8, the hypothesis of random dispersal distance for young screech owls was rejected ($P < 0.001$). It appears that two different groups of young birds are resent in the population a group showing little dispersal (less than 2 km [20 mi]), and a group wandering considerable distances (100 o 300 km [60 to 185 mi]). Similar findings were presented for song parrows by Johnston (1956) and for small mammals by Dice and oward (1951), Howard (1960), and French et al. (1968). These uthors all discussed the possibility that certain individuals within population may desire to move long distances. Whether there is a enetic basis for his behavior, as proposed by Howard (1960), or hether all individuals are subject to this urge at a certain stage of heir lives or season of the year, is uncertain. It should be noted, owever, that about 6% of the screech owls moved beyond the xpected range. The percentage is similar to the 10% reported for ong sparrows in Ohio and California (Johnston 1956). Further-ore, Henny and VanVelzen (1972) indicated that approximately 1% of an osprey (*Pandion haliaetus*) population disperses from heir natal area to breed.

able 8. *Comparison of the observed dispersal distance of nestling screech owls with the Poisson distribution (includes recoveries from 1 October). The adult data are included in parentheses but are not statistically tested as little or no dispersal is indicated.*

Category (miles)	Observed frequency		Expected (Poisson)		X^2
0-10	25 (48)[a]		4.5		93.39
11-20	21 (3)		11.2		8.58
21-30	3 (2)		14.0		8.64
31-40	2 (2)		11.6		7.94
41-50	0		7.2		
51-60	0		3.6		
61-70	1		1.5		
71-80	0		0.5		
81-90	0		0.2		
91-100	0		T		
101-110	0		T		
111-120	1	4	T	13.0	6.23
121-130	0		T		
131-140	0		T		
141-150	1		T		
151-160	0		T		
161-170	0		T		
171-180	0		T		
181-190	1		T		
Total	55		54.3		124.78 ($P < 0.001$)

[a] Number in parenthes refers to 55 recoveries of screech owls banded as adults in March through June.

The rigors of wandering during their first autumn and winter probably imposes considerable hardship on the young owls. Many have not yet located suitable roosting areas or other essential requirements, which may make them vulnerable to severe weather and predation from larger owls. However, it should be noted that theoretically, the apparent nonrandom distance of the dispersal has evolved because of its advantage to the species. Current ideas on nonrandom vertebrate dispersal can be conveniently divided into two viewpoints: (1) those that suggest an "inherent" or "genetic" difference between individuals causing them to be short-distance or long-distance dispersers (e.g., Johnston 1956, Howard 1960, Lidicker 1962), and (2) those that suggest the only difference between individuals is their ability (relative dominance) to procure a residence (e.g., Murray 1967).

The first group tends to think of innate dispersal in terms of benefiting the *population* (in spite of the high rate of mortality of long-distance dispersers). The advantages to the population from such behavioral characteristics are said to be: (1) the increase of gene flow to ensure a tendency toward greater panmixia, (2) the increase in ability to spread its range rapidly as favorable habitats are created and to quickly reinvade areas that may have been depopulated by catastrophes, and (3) the increase in ability to regulate population density below carrying capacity. Murray (1967) tends to think in terms of benefit to the *individuals,* i.e., the dominants that established a nearby residence would be at a distinct advantage. Furthermore, Murray (1967) believes the advantages cited by the first group are actually unselected consequences of selection for individuals that aggressively procure breeding sites but move away from dominant individuals. He concluded by saying there is no reason to believe that selection has occurred above the level of the individual. Although the mechanisms involved in dispersal are not fully understood, the many advantages of such a trait are readily apparent.

Directional Pattern of Dispersal

The directional pattern of screech owl dispersal in the northeastern United States was determined by using all birds recovered outside the 10′ block where banded. Retrapped birds are not included here as they would be biased to the study area. As shown in Table 8, the majority of the birds were reported within 32 km (20 mi) of the banding site.

The apparent dispersal of more birds east and west is a result of the shape of the 10′ blocks at the latitude where the data were collected (Fig. 5). The blocks are rectangular (approximately 21 × 11

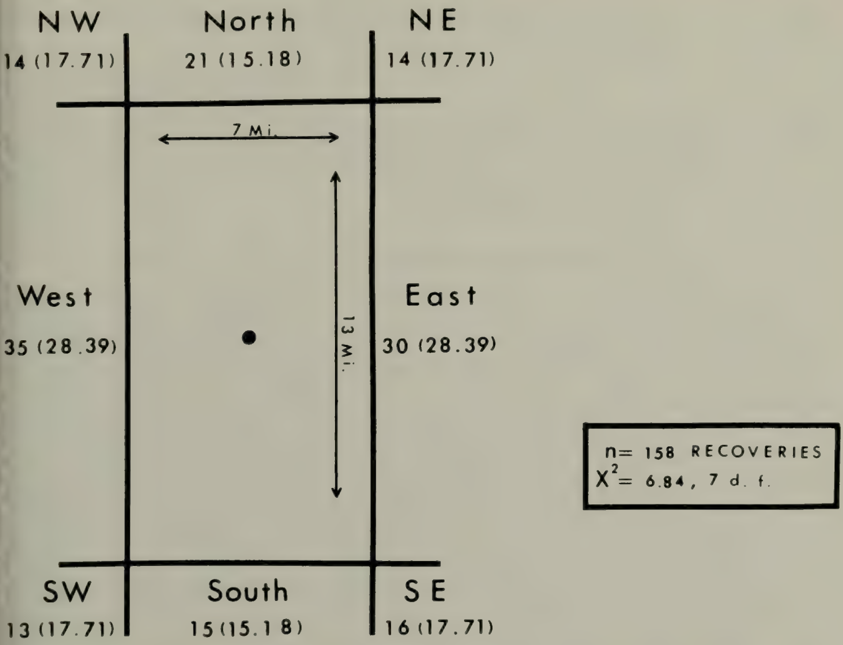

Fig. 5.—The directional preference of screech owl dispersal in the northeastern United States.

km [13 × 7 mi]) and it is a shorter distance (by 53.8%) to an adjacent block if one moves east or west. The data in question are frequencies of recovery in eight recovery areas defined with reference to the 10′ block of banding (Fig. 5). Again, we must assume that banding occurred at the center of the block. Because of the shape of the banding block and the recovery areas, these eight frequencies of recoveries would not have equal expected values, even if dispersal were random with respect to the direction of movement. The problem here is to ascertain if the data obtained are consistent with random direction of dispersal.

We computed the distribution of such recovery frequencies conditional on the dispersal distance given a random direction of dispersal.[1] This computation then allowed a test of the null hypothesis that direction of dispersal is random.

Given the length and width of the 10′ block of banding, and a set of distances for a corresponding set of frequencies, the expected frequencies can be computed under the hypothesis of random direction of dispersal. The formulae are not complex, except for requiring some inverse cosines. The theoretical frequencies of recovery by area are shown in parentheses in Fig. 5. The null hypothesis of random directional dispersal is not rejected ($X^2 = 6.84$, 7 df, $P = 0.50$). Therefore, we conclude that the direction of dispersal of the screech owl is random.

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[1] For additional details, see Memorandum in files at Migratory Bird and Habitat Research Laboratory, "Distribution of band recovery frequencies for the screech owl data." dated 20 May 1974.

Records of Individual Birds

Multi-recaptures on our study area in northern Ohio provided some additional information on movement or lack of movement in adult birds. Generally, after an adult bird established a nesting site, it was found only at that site in future years. For example, an adult female was brooding five young in a box on 12 May 1952. The bird was also found in the same box in 1954 (brooding five young), in 1957 (brooding three young), and 1959 (brooding four young). The bird was found dead in the immediate vicinity of the nest site on 31 March 1960. Records of this type were very common during the study. One of the longest records for an individual owl was a female that was banded in a box on 19 November 1945 and was retrapped eight times at the same nest box before it was killed by a car on 12 February 1958 (approximate age 13 yr) 400 m (0.25 mi) from the nest box. Figure 6 shows a banded screech owl being released at its nest box.

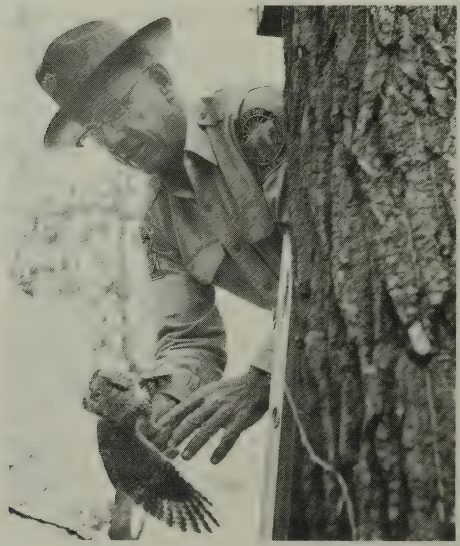

Fig. 6.—A banded screech owl being released at its nest box by the senior author (*photo courtesy of George Laycock*).

BREEDING BIOLOGY

Breeding Season

Carpenter (1883) discussed the breeding of a pair of screech owls that raised a brood of young in captivity in Massachusetts. He indicated that by 1 February 1883 the actions of the adult birds toward each other began to change and they became more attentive to each other. A clutch of three eggs was found on 15 April and incubation lasted 22 days. Kelso (1944) reported paired owls at Ithaca, New York, by 19 February, but egg-laying did not commence until 15 March. Sherman (1911) reported the first egg of a clutch laid on 27 March 1910 (apparently in Iowa) and that a complete clutch of four eggs was found on 4 April. The first two eggs hatched on 27 April and the remaining two on the next 2 days (26-day incubation period). She reported the birds leaving the nest 30, 31, and 32 days after hatching. Kelso (1950) reported screech owls in New York leaving the nest in 31 to 35 days. Bent (1938) indicated that the incubation period is variously reported as lasting from 21 to 30 days, but that the average is probably around 26 days as determined by Sherman (1911). Craighead and Craighead (1956) studied 28 nests in Superior Township, Michigan, in 1942 and 1948. They reported that the first selection of territories began in late February. The earliest egg-laying date was 18 April and the earliest hatching date was 12 May. The mean date for the broods leaving the nest was 1 June.

During our study, pairs of owls were first seen together in the nest boxes as early as 1 and 3 February; egg-laying began considerably later. The chronology of the nesting season in northern Ohio may be determined from the data in Table 9. Small young (1 to 10 days old) were first seen in the nests during 11–20 April; however, the majority of small young (70%) were found during 21 April-10 May. Therefore, most of the eggs were hatched from 15 April-5 May. Assuming a 26-day incubation period, egg-laying began about 15 March for the majority of the population with a few laying 5 to 10 days earlier. A few small young were seen as late as the first week in June. These young were probably the results of renesting efforts. Thus, most young in the northern Ohio fledge during the last week of May or the first week of June. The young attain a bandable size with their color readily apparent at about 3 wk of age (10 days before fledging).

Table 9. *Percentages of three size categories of young screech owls in 10-day periods during the brooding season in northern Ohio.*

Date	Small young (≃1-10 days old)	Medium young (≃11-20 days old	Bandable young (≃21-30 days old)
11-20 April	6	0	0
21-30 April	33 [a]	4	5
1-10 May	37	62	17
11-20 May	18	28	43
21-31 May	5	6	30
1-10 June	2	0	4
11-20 June	0	0	1
Number of nests in sample	101	71	440

[a] Longitudinal line refers to peak period for young in each size category, which in turn documents the progression of the breeding season.

Clutch Size

Bent (1938) indicated that screech owls lay three to seven eggs, but usually four or five, with the average in favor of five. He further indicated that the extremely large or small sets are rare, and the reports of eight or nine seem doubtful. The average clutch in our study was 4.43 (Table 10).

Among egg sets from 12 museums in the eastern half of the United States, the largest clutches were found in the north-central part of the region and the smallest in the Southeast (Table 10). This suggests a clinal pattern in which clutch size, in general, increased from east to west and from south to north. One unusual clutch of 10 eggs was found during our study. The bird was incubating on 2 May 1967 and three medium-sized young were found in the nest on 18 May. Two birds probably laid the eggs. We banded seven young in another nest on 7 May 1954. Since this was our only record of seven young in a nest and there were no infertile eggs found, it is probably safe to assume that the clutch size was seven. The record of this nest is not included in the table, however, because it was not visited when eggs were in the nest. Little effort was made to obtain information on clutch size during our study because disturbance during the incubation period seemed to cause nest abandonment.

Table 10. *Clutch sizes of screech owls in northern Ohio compared with egg sets in 12 museums (nearly all museum sets were collected before 1900).*

	Clutch size									
Location	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**n**	**Mean**
Northeast[a]	0	3	17	36	28	8	0	1	93	4.27
Northern Ohio[b]	0	1	10	37	35	8	0	0	91	4.43
Northcentral[c]	0	0	2	7	6	3	0	0	18	4.56
Midwest[d]	0	1	6	5	3	0	0	0	15	3.67
Arkansas-Oklahoma-Texas	0	0	7	9	0	0	0	0	16	3.56
Georgia-South Carolina-Tennessee	0	2	5	3	0	0	0	0	10	3.10
Florida	1	13	32	7	4	0	0	0	57	3.00

[a] Massachusetts, Rhode Island, New York, Pennsylvania, New Jersey, Maryland, and Washington, D.C.

[b] Does not include one clutch of 10 eggs.

[c] Ohio, Indiana, Illinois, and Wisconsin.

[d] Missouri, Iowa, Kansas, and Nebraska.

Nesting Success and Fledging Rates

Craighead and Craighead (1956) provide the only estimate of the number of young fledged per nesting attempt; however, their estimate was based on several assumptions because the information from most nests was incomplete. They concluded that between 2.6 and 3.0 young were fledged per pair of adults in Michigan and Wyoming.

Much of our information from nests was also incomplete. Many of the nests were not visited early, i.e., during the incubation period, and some unsuccessful nests were not detected. The number of active nests in 1944–73 (Table 11) partially reflects the authors' effort rather than abundance. From these 440 successful nestings, 1,673 young were believed to have been fledged (3.80 young per successful nesting). The annual variation in numbers fledged per successful nesting was small (coefficient of variation [× 100] of 8.2).

Table 11. *Success of screech owl nests in northern Ohio, 1944-73.*

Year	No. active nests	No. nests successful[a]	Percent of nests successful[b]	No. young fledged	Young fledged per successful nest
1944	4	4	100.0	17	4.25
1945[c]	5	4	80.0	16	4.00
1946[c]	9	6	66.7	22	3.67
1947[c]	19	14	73.7	56	4.00
1948[c]	20	11	55.0	37	3.36
1949[c]	19	15	78.9	61	4.07
1950	26	24	92.3	87	3.63
1951	11	10	90.9	39	3.90
1952	25	23	92.0	85	3.70
1953	34	31	91.2	116	3.74
1954	49	44	89.8	197	4.48
1955	42	42	100.0	161	3.83
1956	22	20	90.9	81	4.05
1957	16	14	87.5	54	3.86
1958	17	14	82.4	50	3.57
1959	15	12	80.0	49	4.08
1960[c]	17	11	64.7	40	3.64
1961[c]	12	9	75.0	32	3.56
1962	20	18	90.0	70	3.89
1963[c]	16	11	68.8	40	3.64
1964	9	9	100.0	34	3.78
1965	8	7	87.5	29	4.14
1966	9	9	100.0	30	3.33
1967[c]	18	16	88.9	54	3.38
1968	13	13	100.0	49	3.77
1969[c]	12	10	83.3	35	3.50
1970	13	12	92.3	45	3.75
1971[c]	13	11	84.6	34	3.09
1972	18	16	88.9	53	3.31
1973[d]	—	—	—	—	—
Total	511	440	86.1	1,673	3.80

[a] Fledged at least one young.

[b] This percentage is biased high because many nests were visited only once when the young attained bandable size.

[c] Years when 75 percent of nests were visited on two or more occasions.

[d] Data excluded because one egg from each clutch was collected for pesticide study.

The banding date disclosed variation in the number of young reported per successful nesting (Table 12). The earliest nesting attempts produced slightly more young than later attempts. This may be partially due to the older, more experienced birds nesting first, whereas the late nests may include more first-year breeders. Also, a few renests with small clutch sizes may have been included in the last category. A brood of five young is shown in Fig. 7.

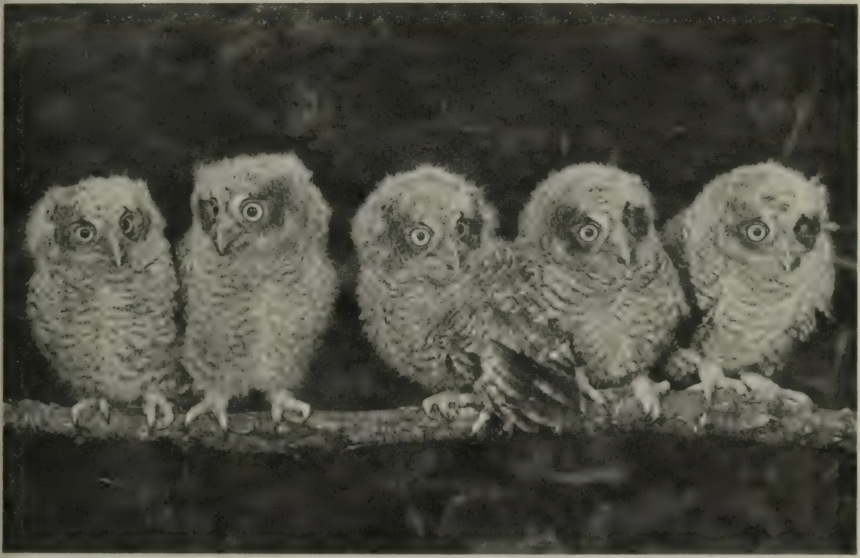

Fig. 7.—Five downy screech owls (*photo courtesy of G. Ronald Austing*).

Table 12. *Number of young screech owls per successful nest during five banding periods (from early to late nesters) in northern Ohio.*

Banding date[a]	Successful nests	Number banded	Mean per nest
22 April — 9 May	88	367	4.17
10 May — 15 May	88	336	3.82
16 May — 19 May	88	335	3.81
20 May — 23 May	88	334	3.80
24 May — 20 June	88	301	3.42
Total	440	1,673	3.80

[a] The banding dates were adjusted so that an equal number of successful nests were reported in each banding period.

Because the data presented in Table 11 include a number of nests that were visited only once, i.e., at the time of banding, a rationale was needed to obtain an estimate of the number of young fledged per breeding pair. The data are obviously an overestimate of the percentage of nesting attempts that were successful. Two methods were used to estimate the number of young fledged per breeding pair: (1) use of only nests with the most complete set of observations, i.e., nests visited initially during incubation, and (2) the Mayfield (1961) Exposure-day Method (and the data which met his criteria).

Nests Visited Initially During Incubation

This method was restrictive and reduced the number of usable nesting records from the total of 511 to 165, which were the most complete ones (Table 13). Because egg-laying in northern Ohio begins about 15 March for most of the population, the nests visited between 18 March and 10 April best represent the fledging rate per nesting attempt (Table 13). The fledging rate estimates for 11–30 April were believed to be inflated because of undetected losses before the first visit to the nest. Thus, we believe the best estimate by this rationale is 2.55 young fledged per pair.

Table 13. *Screech owl nesting success and fledging rates as related to the date the nest was first visited. Only nests with eggs present at first visit were included.*

Date first visited[a]	No. of nests	No. of young fledged	Young fledged per nesting attempt
18 March — 10 April	20	51	2.55
11 April — 20 April	64	178	2.78
21 April — 30 April	81	238	2.94

[a] All years combined.

Mayfield Exposure-day Method

Other field workers have often been faced with interpreting nesting success with data from nests that were not observed from the start of incubation. Further, the sample may include some nests for which success of nesting was unknown. If such partially complete records are included (or excluded) from his calculations, there is a danger of distorting the conclusions. Mayfield (1961) presented a way of dealing with this problem by reducing the data to units of exposure, which reflects not only the number of nests but also the length of time each was under observation. A convenient measure of exposure is the nest-day (equivalent to one nest for 1 day). With this method, all single or multiple observations of individual nests can be incorporated into the sample, even though some of these do not go back to the very beginning or do not carry through to the end. Mayfield (1961) points out that after mortality and survival rates are expressed per nest-day, the probability of survival of eggs and young may be calculated for all or any part of this nesting period. If the survival rate per nest-day is S, the probability of survival of a nest for d days is S^d . Mayfield further pointed out that the survival rate during incubation is different from the rate during the nestling period, so these two stages must be treated separately. Also, egg survival must be considered separately from nest survival because of the loss of individual eggs, particularly at hatching time. The probabilities of survival in different stages of nesting may be combined through the mathematical principle that the probability of a succession of events is the product of their separate probabilities.

We found that only 13 young from successful nestings (nests from which at least 1 young is fledged) were lost in 1,090 exposure days between 1944 and 1973 (loss per exposure-day of 0.012). Furthermore, the loss of young per exposure-day was quite consistent throughout the brood rearing period in successful nestings (i.e., 22 April–9 May—0.010, 10–20 May—0.012, and 21 May–20 June—0.015). Based on a 30-day period for the young in the nest, an estimated 0.36 young was lost per successful nesting from the period of hatching to fledging. Thus, we worked backwards from the number of young fledged per successful nesting (3.80 from Table 11) to determine the number of young hatched per successful nest. This approach was a necessity because of our weak data for early in the incubation period. Early visits had the potential to cause nest abandonment and thus, it was not possible to estimate egg loss on an exposure-day basis. Egg loss in successful nests was estimated by difference. With an estimated 3.80 young fledged per successful nesting, we estimate that approximately 4.16 young hatched per successful nesting from the 4.43 eggs laid (Table 10). Thus, by difference, an estimated 94% of the eggs in successful nests hatched. The loss of young after hatching from broods that were not completely destroyed appeared to be low.

As mentioned earlier, the percentage of successful nesting was overestimated in Table 11, particularly during years when less than 75% of the nests were visited two or more times (Table 11, footnote c). It is most important to obtain an estimate of the percentage of nestings that were successful. Mayfield's (1961) method is again believed applicable. Since few nests were visited more than twice, a problem exists regarding the timing of nest loss.

Therefore, we must of necessity assume that the loss rate of complete nests was constant through time. This assumption may or may not be true; therefore, our recruitment estimates based on this rationale must be regarded as tentative. Our pooled data indicate that during 5,189 exposure days, 34 nests were lost or believed lost (young in 2 nests may have fledged before being revisited; however, we assumed that one nest was successful). An estimated 0.006552 nest was lost per nest-day. With an incubation period of 26 days and a nestling period of 30 days, each nest was susceptible to loss for 56 days. By applying Mayfield's formula, (0.993448^{56}) we estimated that 69.2% of the screech owl nesting attempts in northern Ohio were successful during the study. With 3.80 young fledged per successful nest, an estimated 2.63 young were fledged per nesting attempt based on the Mayfield Exposure-day Approach. This estimate is in close agreement with that of 2.55 fledged young based on a much smaller sample of nests observed throughout the breeding season. In summarizing our data on recruitment, we believe that the best estimate of the number of young fledged in northern Ohio during the 30-yr study was about 2.5 to 2.6 young per nesting attempt.

Causes of Nest Loss

Sixty-six unsuccessful nests were found during our study. The actual cause of nest failure was determined for a few of the nests listed in Table 14. Most of the nests (41) were either deserted or destroyed. Raccoons (*Procyon lotor*) were implicated in the loss of 15 nests, and the eggs failed to hatch in 7 nests. Craighead and Craighead (1956) noted that fox squirrels (*Sciurus niger*) destroyed the eggs of two pairs of screech owls in Michigan and appropriated the nest hollows. They also pointed out that screech owl nests and ranges are commonly within the nesting range of the great horned owl (*Bubo virginianus*) and that young suffer their heaviest mortality soon after leaving the protection of the nest hollow.

Table 14. *Causes for screech owl nests being unsuccessful in northern Ohio, 1944-72.*

Cause of loss	Number of nests
Deserted or destroyed (reason unknown)	41
Raccoon predation	15
Eggs failed to hatch	7
Young dead in nest	2
People (children) took young	1
Total	66

POPULATION DYNAMICS

Sex Ratio in Population

Behavioral differences between sexes are to be expected in most species. Bellrose et al. (1961) described biases involved in sampling waterfowl populations to obtain sex ratios. For waterfowl and many other groups of birds, a bias may result from (1) a differential migration of the sexes (time of year sample collected), (2) the type of area where collection was made (characteristics of the habitat), or (3) a differential vulnerability of the sexes to the method of collection (e.g., shot, trapped, etc.).

The information on screech owls concerning sex ratios may also be biased, although the nonmigratory characteristic of the species tends to minimize several potential biases. The sex data were obtained from the stomach content records filed at the Patuxent Wildlife Research Center. Not all records contained information on sex. To eliminate one potential bias, the information from March through June (the nesting season when the female was probably on the nest) was eliminated from the sample. Thus, for July to February, of 234 screech owls collected in the northeastern United States, 113 (48.3%) were males and 121 (51.7%) were females. The sample did not deviate significantly from the expected 50:50 sex ratio (chi-square = 0.13, 1 df).

Data obtained in our study area could not be analyzed for sex ratio information because of the potential bias associated with the sampling scheme (nearly all birds captured at nest boxes were paired).

Mortality Rates

Mortality rates for the screech owl have not been estimated previously. In this study, life tables were made from band recovery data in northeastern United States and Ontario; a large percentage of the data came from our study area. Recoveries were not included if information was insufficient to tell if the bird was dead or alive and released. Also, all retrapped birds, sight records, and skeletal remains were omitted. Nestlings were generally banded about 10 days before fledging and, therefore, recoveries during the first 10 days after banding were not included. An initial date (the date after which recoveries would be used in the life tables) of the first 15 May after banding was used for the adults, as opposed to 1 January, because we believe that the nonmigratory screech owl does not attain an adult mortality schedule by 1 January. Henny (1972) indicated that most migratory passerines achieve a schedule of adult mortality by the first 1 January after hatching; however, the more sedentary species (e.g., cardinal, black-capped chickadee [*Parus atricapillus*] blue jay) in the northern portion of the United States do not attain their schedule of adult mortality rates until later. This phenomenon was first reported for the sedentary California quail (*Lophortyx californicus*) by Emlen (1940).

Nestlings and adults banded through 1964 and recoveries processed through August 1974 were included in the analysis. It is believed that the life span of the banded cohort was nearly completed by 1974 as only two recoveries greater than 9 yr of age have been reported during the last 50 yr. However, the possibility still exists that the mortality rate estimates from the composite dynamic life table (Hickey 1952) may be biased slightly on the high side.

Mortality rate estimates shown in Table 15 suggest that approximately 32.8 to 39.0% of the adult population dies annually. The range in the estimates of adult mortality rate is undoubtedly due to small sample sizes, particularly for the cohort banded as nestlings. Probably the best estimate of adult mortality rate would be based on the pooled recoveries from bandings of both nestlings (second year and later) and adults. The combined data yielded an annual adult mortality rate estimate of 33.9%. The first-year mortality rate for young birds is much higher, about 69.5%.

Table 15. *Estimates of mortality rates for screech owls banded as nestlings and adults in the northeastern United States and Ontario during 1915-64.*

Age interval years	Adults[a] Number of recoveries	Alive at beginning	Mortality rate	Nestlings Number of recoveries	Alive at beginning	Mortality rate
0–1	55	134	0.328[b]	73	105	0.695[c]
1–2	25	79		13	32	0.390[b]
2–3	13	54		7	19	
3–4	9	41		4	12	
4–5	7	32		2	8	
5–6	8	25		2	6	
6–7	6	17		3	4	
7–8	3	11		1	1	
8–9	5	8		0	0	
9–10	1	3		0	0	
10–11	1	2		0	0	
11–12	0	1		0	0	
12–13	1	1		0	0	

[a] An initial date of the first 15 May after banding was used for all birds not banded as nestlings. On this date, the birds were arbitrarily classified as adults.

[b] Annual adult mortality rate estimate.

[c] First-year mortality rate estimate.

Causes of Postfledging Mortality

Band recoveries provide some information on causes of mortality, although dead owls found by humans are not a random sample of the mortality occurring in a population. For example, predation by other raptors would most likely be undetected because the carcasses would disappear before being found. Actually, most bands reported to the Bird Banding Laboratory are from birds that died as a result of man's activities (his vehicles, pets, etc.). Furthermore, the majority of the bands are reported as found on dead birds with no cause of death mentioned.

Screech owls hit by motor vehicles and found along roads appear frequently in the sample reported to the Bird Banding Laboratory (Table 16). Sutton (1927) reported 113 requests for permits to retain specimens of the screech owls which had been found dead or in weakened or wounded condition in Pennsylvania. The causes of death included 6 which may have died of starvation or illness, 2 which had flown into window panes, 7 which were caught by steel traps, 1 which had been killed by the felling of a tree, 13 which had been shot, 2 which were alive but in poor condition, and 82 which evidently were killed by flying into automobiles. Schorger (1954) recorded 235 road-killed screech owls during a period of 18 yr between Madison, Wisconsin, and Freeport, Illinois; Stupka (1953) examined 41 screech owls along the highways in or near Great Smoky Mountains National Park. Both Sutton (1927) and Stupka (1953) believed that in most instances these birds were struck and killed while feeding upon prey, primarily insects, along highways.

The recovery data submitted to the Bird Banding Laboratory, as anticipated, suggested that predation on the screech owl by other raptors was of minor importance. Craighead and Craighead (1956), however, indicated that the screech owl was fairly vulnerable to the great horned owl because both often hunt the same habitat.

The importance of the various mortality factors affecting a screech owl population cannot now or perhaps ever be determined. However, it is important to recognize that man, his machinery, his vehicles, his pets, and his buildings and other structures do take their toll; at the same time, it should be understood that many of man's alterations of the habitat have benefited the screech owl. Numerous authors have stated that screech owls seem to take kindly to man's occupation of the land and breed and thrive in the vicinity of his dwellings, in spite of the injudicious warfare which is sometimes waged against them.

Table 16. *Circumstances that led to the deaths of banded screech owls reported to the Bird Banding Laboratory.*

	Month of recovery												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Found dead													
(no cause reported)	15	21	27	21	22	25	16	17	12	16	23	15	230
Killed by motor vehicle	3	7	9	3	3	5	7	4	5	4	3	15	68
Misc. or no information	4	7	10	4	8	5	7	3	2	3	7	2	62
Shot	6	3	4	1	3	8	4	2	3	4	4	5	47
Found in building	2	3	5	1	1	1	2	2	4	5	—	—	26
Drowned	—	—	1	2	2	—	2	3	—	—	—	—	10
Killed by dog or cat	2	1	—	1	1	—	—	—	1	1	—	—	7
Flew into object	2	1	—	—	1	—	1	1	—	—	1	1	8
Trapped or snared													
(Not used for bird banding)	3	1	1	1	—	—	—	—	—	—	1	1	8
Sick bird	1	—	1	—	—	2	1	—	—	2	—	1	8
Killed by train	1	—	2	—	—	—	—	—	—	1	—	—	4
Killed by hawk or owl	1	—	—	—	—	—	—	—	1	—	—	1	3
Total	40	44	60	34	41	46	40	32	28	36	39	41	481

ge at Sexual Maturity

The age at sexual maturity is one of the most important and ifficult parameters to determine for a wild population of birds, and ublished information on the subject for the screech owl was not vailable. Screech owls were recorded breeding as 1-yr-olds on 10 ccasions (7 females and 3 males) during our study, and 3 other 1-r-olds were found in nest boxes in April but with no sign of eggs or mate. These birds were all banded as nestlings and found the ollowing spring. Of particular interest was a 1-yr-old male that nated with its mother in 1971 and produced one young. Nestings vhere a 1-yr-old was involved fledged 3.55 young per successful ttempt (slightly lower than the 3.80 average for the population, able 11). Ten is a small number to have of definite records of 1-yr-lds breeding considering the amount of time spent in the field luring the 30-yr study; however, it must be remembered that the oung disperse during the late summer and early fall (Table 7). hus, the chance of recapturing a banded 1-yr-old screech owl in nother nest box is remote.

As well as establishing the capability of 1-yr-olds to breed, we eed to know the percentage that do breed at this age. Of 13 1-yr-lds found during the nesting season, 10 (77%) were nesting. This stimate may be biased because other nonbreeding 1-yr-olds may ot associate with nest boxes and therefore be undetected. Another pproach is to compare the number of breeding 2-yr-olds found esting during the study with the number of 1-yr-olds found esting. Then, given the average annual adult mortality rate of pproximately 33.9% (from previous section), and given that eight -yr-olds were found nesting, we estimated that there should be a otal of 12.1 breeding 1-yr-olds located if all 1-yr-olds and 2-yr-olds ttempted to nest. Of course, only 10 were found, which provides an stimate of 83% (10/12.1) of the 1-yr-olds attempting to nest nnually.

Conclusions regarding the percentage of the 1-yr-old screech wls that attempt to nest annually must be regarded as tentative at his time. Furthermore, the percentage may fluctuate from year to ear. Our two estimates (based on very small sample sizes) suggest hat an average of possibly 77 to 83% of the 1-yr-olds attempt to nest nnually, but the percentage may be lower.

In comparison, Henny (1972) summarized information from everal published and unpublished sources on age at sexual naturity of great horned owls. He concluded that most individuals lo not breed until they are 2-yr-olds, although an average of about ne-fourth of the population nests as 1-yr-olds, with the percentage varying from year to year depending upon local conditions. Similar but more dramatic findings have been reported for other owls that are primarily dependent upon one food source. Barn owls (*Tyto alba*) were reported to nest at the end of their first year of life (Schneider 1937, Stewart 1952); however, in general, barn owls seem to breed irregularly. Wallace (1963:209) stated, "The barn owl may breed almost continuously during peak years in the *Microtus* (meadow mouse) cycle, but slow down or skip a breeding season when its staple prey is scarce." Similar observations were recorded for the tawny owl (*Strix aluco*) in England. Lack (1966) reported that 59% of the population was breeding pairs, but the percentage that nested in specific years ranged from 0 to 90%. Increases in clutch size also were reported for some species of owls in years when rodents were abundant. Lack (1968) reported that the short-eared owl (*Asio flammeus*) may lay nine eggs during a vole plague, but only about half that many during other years.

The number of young fledged per successful screech owl pair was very consistent from year to year (Table 11). This is probably the result of the species being an opportunistic feeder. We do not believe that large numbers of breeding-age screech owls fail to produce in years when the local rodent cycle is low, although rodent cycles may have some influence on 1-yr-olds. Unlike the barn owl, tawny owl, and short-eared owl, the screech owl is not totally dependent upon local rodents (or one genus of mouse) for its food supply. In fact, the young are fed a diet which consists largely of small birds of many species which migrate through the area (Table 2). Thus, the varied food supply for the young is not produced locally; it is highly dependable and actually migrates to the owl's hunting areas annually from numerous places, some being considerable distances away. The opportunistic feeding habits of the screech owl apparently tend to maintain a very uniform reproduction annually and, to our knowledge, nonbreeding is limited to a small percentage of the 1-yr-olds. We must caution, however, that more research is needed on sexual maturity.

PESTICIDES AND POLLUTION

Eggshell thinning has been found to occur widely and is well documented, especially in the United States and England. In the United States, natural populations of at least 22 species representing seven orders have been affected. In seven of eight species where shell thinning exceeded 20%, there was an associated population decline (Anderson and Hickey 1972). The thinning began to occur in the United States and England in the mid-forties at the time DDT and other organochlorine insecticides were first available for widespread use (Ratcliffe 1967, Hickey and Anderson 1968). The possible relationship of shell thinning to the use of DDT led to a series of studies to test the effects of DDT and its metabolites on shell thinning and reproduction of birds.

Initial laboratory studies were conducted on mallards (*Anas platyrhynchos*), black ducks (*Anas rubripes*), and American kestrels (*Falco sparverisu*) and showed a direct causal relationship between DDE and eggshell thinning (Heath et al. 1969; Longcore et al. 1971; Wiemeyer and Porter 1970). The next species to be studied in a similar manner was the screech owl (McLane and Hall 1972). The owls were given a dietary dosage of 2.8 ppm of DDE (equivalent to 10 ppm dry weight). Birds fed untreated food in 1970 and DDE dosage in 1971 laid eggs with shells that were 12% thinner than in 1970. McLane and Hall (1972) concluded that screech owls seem to show greater shell thinning than American kestrels which showed 10% thinning on a similar diet (Wiemeyer and Porter 1970).

Eggshell Thinning

The work by McLane and Hall (1972) indicated that screech owls were susceptible to the eggshell thinning phenomenon. In cooperation with the Patuxent Wildlife Research Center, one egg was collected from each of the 21 clutches on our study area in 1973. The eggs were measured for eggshell thickness and analyzed for chlorinated hydrocarbon residues. The remainder of the clutch was observed for hatchability and fledging rates. Klaas and Swineford (In preparation, Patuxent Wildlife Research Center) compared shell thickness in these 1973 eggs with shell thickness in eggs collected before 1947 in Ohio (Table 17). No significant decrease in eggshell thickness in the 1973 population was detected.

Eggshells collected from the field in 1973 were about 8% thicker than the controls in the laboratory experiment (Table 17). This is of interest because many of the owls in the laboratory experiment were obtained from our study area in northern Ohio in 1967. The reason for the thinner control eggs in the laboratory study is unknown, but it may be due to a number of factors (e.g., age of birds, diet, etc.).

Table 17. *Shell thickness of screech owl eggs.*

Location	No. of females	No. of eggshells measured	Shell thickness (mm) Mean	(S.E.)	Range
Laboratory experiment[a]					
Controls	14	66	.218		.180-.253
Experimental (DDE)	6	28	.189[b]		.170-.205
Field study[c]					
Pennsylvania pre-1946[d]	37	37	.241	.003	.197-.277
Ohio pre-1946[d]	12	12	.244	.004	.230-.287
Ohio 1973 (random, early)[d]	19	19	.234[f]	.004	.197-.260
Ohio 1973 (addled)[e]	8	16	.243[f]	.007	.157-.270

[a] Patuxent Wildlife Research Center (McLane and Hall, 1972).

[b] Significantly different from shell thickness of controls ($P < 0.05$).

[c] Klaas and Swineford (In preparation, Patuxent Wildlife Research Center).

[d] One egg selected at random from each clutch in early stages of incubation, but after clutch was completed.

[e] Unhatched eggs removed from nest after incubation was complete. Includes 11 eggs from three clutches in which no eggs hatched.

[f] No statistical differences were detected in the means for the four groups of eggs. t-test ($P > 0.1$).

Residue Levels in Eggs

The 19 fresh eggs collected early in the nesting season and an additional 16 addled eggs found in the same nests at the end of the 1973 nesting season were analyzed for chlorinated hydrocarbons (Klaas and Swineford, in preparation, Patuxent Wildlife Research Center). DDE and polychlorinated biphenyls (PCB's) were found in all 35 samples (Table 18), although the levels were generally low, as expected in view of the lack of eggshell thinning in the population (Table 17). Eight eggs in the sample (all from separate clutches) contained dieldrin (range 0.10-0.24 ppm).

Table 18. *Residue levels of DDE and PCB's in 35 screech owl eggs collected in northern Ohio, 1973 (from Klaas and Swineford in preparation, Patuxent Wildlife Research Center).*

Category	Arithmetic mean[a] (ppm)	Range (ppm)
DDE	1.29	0.33–2.8
PCB	1.32	0.26–3.4

[a] Wet weight.

Numerous authors have stated that bird-eating and fish-eating aptors usually build up higher residues and have greater shell hinning than do rodent-eaters (review by Stickel 1973). Why did he screech owls, whose diets contained large quantities of migrant irds, not display these characteristics? We can only speculate that he lack of shell thinning and high egg residues in the Ohio opulation was because the eggs were laid before the predominance f avian prey became available to the owls. The owls just prior to nd during the egg-laying period were feeding primarily on odents. Thus, the seasonal pattern in the food habits of the screech wl may be offering the species some protection against the ccumulation of high pesticide loads.

Eggs in three clutches contained the organochlorine pesticide nirex (three eggs in one clutch, mean 0.10 ppm, one egg in another lutch, 0.12 ppm, and one in another clutch 0.16 ppm). Mirex has timulated considerable controversy during the past several years ecause of its actual and proposed widespread aerial application hroughout the southeastern United States to control the imported ire ant (*Solenopsis saevissima richteri*). Recent laboratory studies y Heath and Spann (1973), however, showed no perceptible eproductive effects on bobwhite quail (*Colinus virginianus*) or nallards. Since mirex spray activities have been confined to the outheastern United States, we believe the screech owls in northern)hio obtained their mirex from migratory passerine birds that vintered in the Southeast. The diet of screech owls during certain eriods of the year consists mainly of migratory passerines Table 2).

POLYMORPHISM

The existence of bimodal or polymodal variation within a species referred to as polymorphism, in which intermediate forms occur t low frequency or are even absent (Owen 1963b). Polymorphism nay be defined as the occurrence together in the same habitat of wo or more distinct genetic forms of a species of animal or plant in uch proportions that the rarest of them cannot be maintained by ecurrent mutation (Ford 1940). Differences between the sexes, etween young and older individuals, and among seasons are xcluded from this definition. Hence, an extremely variable species nay not necessarily be polymorphic. Huxley (1955) provided an utline for the analysis of polymorphism which included among ther items: (1) the ecogeographical mapping of morph-frequency nd determination of ratio-clines (if present, this should be epeated at regular intervals), (2) experimental and statistical evaluation of viability and other intrinsic or extrinsic selective advantages of the morphs concerned, and (3) genetical analysis of the underlying balance and stability mechanisms. In evaluating polymorphism in the screech owl, we attempt to follow the outline presented by Huxley.

The existence of two distinct color forms of the screech owl has been known since about 1874 when Ridgway (Baird et al. 1874) realized that rufous and gray birds were of the same species and that the forms were independent of age, sex, or season. Earlier, rufous and gray birds had been variously interpreted as belonging to different sexes or to different age classes (review by Hasbrouck 1893). Ridgway later published in many natural history and scientific journals an appeal for information on the frequency of rufous and gray birds, nesting information, and any other data that might help to solve the problem. The information was passed over to E. M. Hasbrouck who published an account of his findings (Hasbrouck 1893). A number of inaccuracies in Hasbrouck's paper were pointed out at the time in a critical review (Allen 1893). It was 70 yr until another full survey of the geography of color forms in the screech owl was attempted (Owen 1963b), although several authors discussed small geographic areas (Martin 1950, Schorger 1954, Hrubant 1955).

Owen (1963b:189) summarized his description of geographical trends in the occurrence of color forms of the screech owl as follows:

> "Throughout most of North America east of about 104° there are two forms of the screech owl: one with the plumage mainly bright rufous and the other with the plumage mainly gray. Birds of intermediate coloration also exist, but in most areas they are rare. The relative frequency of rufous birds varies geographically in the form of a cline from north to south; about a quarter or less of the northern population is rufous, while in the south (the Gulf coast and Florida excepted) up to three quarters of the population may be rufous. . . . The geography of polymorphism in the screech owl appears to be an unusual pattern of variation within an animal species."

Owen (1963b) indicated that the presence of polymorphism in the screech owl probably represents balanced adaptation of the forms to varying environmental conditions. After noting that the adaptive significance of the polymorphic forms was not understood, Owen indicated that a cline in the relative frequency of the forms as opposed to random or irregular distribution supports the view that polymorphism in the species is maintained by selection operating along environmental gradients. Fisher (1930) ndicated that it is extremely unlikely that two or more very ifferent phenotypes would be equally adapted to the environment n which they live; a balance of selective forces must be involved, or if not, one form would rapidly replace the other and there would e no polymorphism.

nnual Variation in Color Phase Ratios

Hasbrouck (1893) and Owen (1963b) studied the general patterns n the geographical occurrence of the two color phases of the creech owl. However, to explore the factors responsible for the atterns observed, we believed it would be fruitful to study yearly luctuations in a given population, preferably one near the edge of ts range. Although the screech owl's range extends into southern ntario (Godfrey 1966), our study area in northern Ohio was ufficiently close to the northern edge of the range that yearly luctuations were probable. During our 30-yr study, more than ,000 observations of screech owls allowed us to assess fluctuations n the composition of the two morphs within the population.

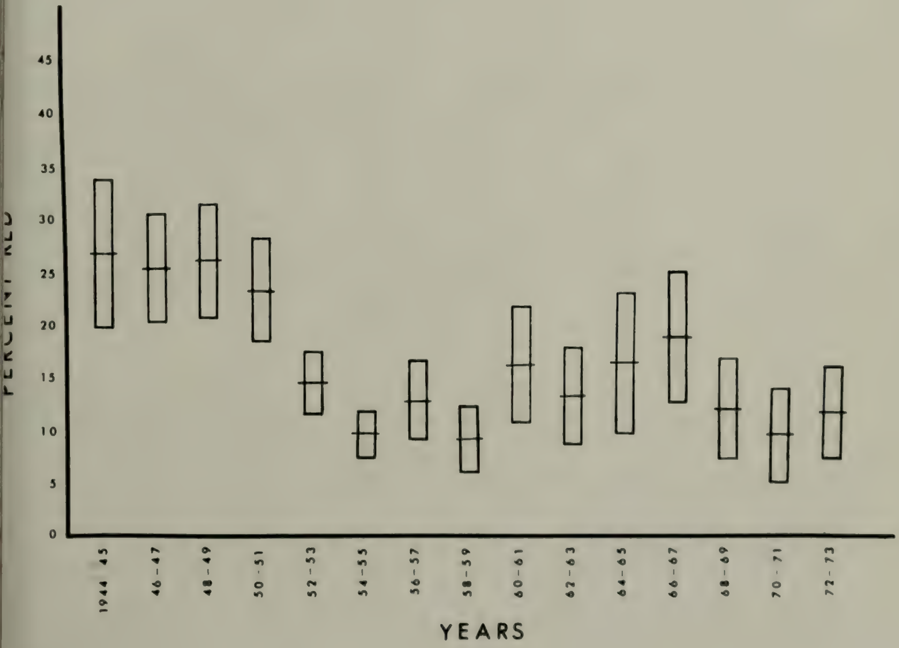

Fig. 8.—Changes in the color phase ratios of screech owls in the northern Ohio study area, 1944–73 (*mean with 95% CI*).

The population during the first 8 yr of the study (1944-51 consisted of about 25% red-phase birds. During December 1951, the percentage of reds decreased significantly (Table 19, Fig. 8). No significant annual change in the color phase ratio occurred during the remainder of the 30-yr period, although the red phase seemed to increase slightly during the early and mid-1960's. Owen's (1963b suggestion that environmental gradients were probably responsible for the clinal pattern observed in North America led us to review weather data. The Toledo weather station (Toledo Express Airport is within the study area and monthly summaries for the 30 winters (November-April) were obtained for that station from the National Weather Records Center (Asheville, N.C.). The deepest snowfall during the 30-yr study occurred in December 1951 as a snowcover of 10.16 cm (4 in) or more lasted for 17 days, averaging 21.34 cm (8.4 in (25.40 to 33.02 cm [10-13 in] on the ground for 6 days). The snow was accompanied by below-normal temperatures; the lows during the first 15 days of the snowcover averaged -15C and for 4 days the temperature was below -18C.

Table 19. *A summary of the color phase percentages of screech owls by 2-year periods in the Ohio study area. (Includes retrapped birds banded in previous years.)*

Years	Percent red	Percent gray	Number observations	Standard deviation	Percent red 95% C.I.
1944–45	26.8	73.2	149	3.63	19.7 to 33.9
1946–47	25.5	74.5	267	2.67	20.3 to 30.7
1948–49	26.2	73.8	267	2.69	20.9 to 31.5
1950–51	23.3	76.7	275	2.55	18.3 to 28.3
1952–53	14.7	85.3	537	1.53	11.7 to 17.7
1954–55	9.8	90.2	695	1.13	7.6 to 12.0
1956–57	13.0	87.0	300	1.94	9.2 to 16.8
1958–59	9.3	90.7	323	1.62	6.1 to 12.5
1960–61	16.5	83.5	176	2.80	11.0 to 22.0
1962–63	13.6	86.4	206	2.39	8.9 to 18.3
1964–65	16.7	83.3	120	3.40	10.0 to 23.4
1966–67	19.2	80.8	156	3.15	13.0 to 25.4
1968–69	12.3	87.7	179	2.46	7.5 to 17.1
1970–71	9.8	90.2	174	2.25	5.4 to 14.2
1972–73	11.9	88.1	218	2.19	7.6 to 16.2

The combination of heaviest snowfall during the study and extremely cold weather seemed to be correlated with the only significant change in color phase ratios during the 3 decades. Thus, we hypothesize that heavy snowfall in combination with low temperatures plays a direct or indirect role in the relative abundance of the two morphs in the northern portion of the range. The gray phase, which is more abundant in the northern latitudes where winters are more extreme, seemed to survive the critical period much better than the red phase.

Retrap records of adult screech owls banded on the study area before the extreme winter provided information about relative survival of the two color phases during December 1951. Adult birds banded during 1947-50 were used in the analysis, and retrap records during 1952 or later were considered envidence of possible differential survival of the two morphs during the critical period of December 1951 (Table 20). This admittedly small sample suggests that 44% (10.8–6.0/10.8 = 44%) more red-phased birds than grays were lost during the interval which corresponds quite well with the drop in the ratio of reds from 1950–51 to 1952–53 (change from 23.3 to 14.7, a drop of 37% [23.3–14.7/23.3=37%]).

Table 20. *A comparison of adult screech owls banded in 1947–50 and retrapped in 1952 or latter*[a].

Category	Red	Gray
Number banded	50	157
Number retrapped	3	17
Percentage retrapped	6.0	10.8

[a] Only banded birds retrapped at least once after banding were included (they may have been retrapped initially at any time).

A comparison between the two phases was then made for adult birds banded between 1953 and 1970 to determine if the gray phase birds were always retrapped at a higher rate than the red phase. The percentage of birds retrapped 2 or more yr after banding was nearly identical for both color phases during the 18-yr period (Table 21). This lends further support for our differential survival hypothesis for December 1951. Differential survival, of course, would lead to a change in the ratio of the two morphs. No significant change in the ratio of the two morphs was observed between 1952–53 and 1972–73 when each morph was retrapped in nearly identical percentages.

Table 21. *A comparison of adult screech owls banded in 1953–70 and retrapped 2 or more years after banding*[a].

Category	Red	Gray
Number banded	120	831
Number retrapped	9	65
Percentage retrapped	7.5	7.8

[a] Only banded birds retrapped at least once after banding were included (they may have been retrapped initially at any time).

It is tempting to speculate about the population composition over the last 40 or 50 yr in light of snowfall patterns. Based on records for the study area during the last 85 yr, snowfall was less than normal during 1920–50 and more than normal during the last 20 yr. The less than normal snowfall during the 25 yr before the study began may have allowed the red phase to increase in abundance; then, the severe weather in December 1951 directly or indirectly seems to have caused a decrease in the red-phased segment of the population. The more than average snowfall during the next 20 yr may be responsible for maintaining the population composition at the lower ratio of red to gray phases, although a hint was present that the red phase attempted to increase in abundance at times.

The ruffed grouse (*Bonasa umbellus*), another polymorphic species in North America, has a somewhat similar clinal pattern in color phase ratios (red and gray) within its range and some knowledge is available for this species. Gordon W. Gullion has worked for many years with survival rates of grouse, including survival related to color phase. Gullion and Marshall (1968:157) stated, "As a generalization, the prevalence of red-phase grouse in the population increases as the climate grades from the Arctic south. This suggests that the difference in mortality may be related to the severity of the winter; or more specifically, that there may be a color-linked susceptibility to cold or other climatic conditions, which selects against the red-phase grouse." Gullion (1966) indicated that during winters which lacked sufficient snow for burrowing, mortality among red-phase grouse was greater than among gray birds, but with better snow conditions the red-phase birds outlived the gray.

Gullion and Marshall (1968:157) indicated, "Earlier we believed that this differential survival represented periodically increased vulnerability to predation among red-phase birds (primarily as a result of insufficient burrowing snow), and we still cannot discount this idea entirely. . . . We have suggested that the red-phase rouse may be more conspicuous to raptors hunting overhead than re the gray-phase birds.” Thus, in summary, the increased ortality of the red-phase grouse may be due to a color-linked usceptibility to severe weather or a predation problem associated ith color-linked vulnerability. The same conclusions seem to be pplicable to the screech owl; in years of heavy snowcover, the red hase screech owls appear to be more prone to mortality because hey have not developed the burrowing behavior of the ruffed rouse. The most important natural predator of the screech owl ould probably be the great horned owl (Craighead and Craighead 956), but we are doubtful that predators over a very short term ould be responsible for the major change in color phase ratios in 951. Lustick (1969) studied the effects of artificial radiation on bird nergetics and concluded that radiant energy reduces oxygen onsumption in birds and that the reduction is correlated with eather color, being greater in dark birds. Mosher and Henny (in ress) recently conducted metabolic experiments with screech owls attempt to ascertain the mechanism responsible for the change color phase ratios in the population in 1951 by exposing birds of he two color phases to various temperature regimes. These data emonstrated a significant difference in oxygen uptake between olor phases at -10 and -5C. This supports the hypothesis that red-hase screech owls are restricted in their northern distribution by olor related metabolic differences from the gray-phase birds. It so suggests that the extremely cold temperatures for a prolonged eriod of time in December 1951 were responsible for excessive ortality of red-phase birds.

ex, Age, and Color Phase

Baird et al. (1874:51) first concluded that plumage color was dependent of sex and age when they stated, “These two very fferent plumages are entirely independent of age, sex, or season, nd that they are purely individual there can be no doubt, since in he nest there may often be found both red and gray young ones, hile their parents may be either both red or both gray, the male d and the female gray, or *vice versa*.” To our knowledge a large mple of birds from a given area has not been available to etermine if the color is independent of sex. Hasbrouck (1893) resented data showing the relation of color to sex based on 646 rds from throughout the breeding range, but since it is doubtful at each sex was sampled equally throughout the species range, lid comparisons could not be made. Martin (1950) compared 75 udy skins from Ontario and found no significant relationship between sexes and color phases. Similarly, we detected no signi cant relationship between sex and color phase in our sample of 7 nesting screech owls (Table 22). Fewer males were in the samp because they were often away from the nest at the time it w visited.

Table 22. *The color phase composition of adult nesting screech owls, 1944- (includes pairs in which the male was unknown).*

	Gray	Red	Percent red[a]
Males	220	40	15.4
Females	403	97	19.4

[a] No significant difference in color phase composition of nesting males a females (chi-square 1.87, 1 df NS). The intermediates were not included here.

The red and gray birds were found in almost identical ratios both breeding populations and the young birds produced (Tab 23). The intermediates were also consistent in both age categori (2.6 and 2.3%).

Table 23. *Classification of screech owl color morphs from northern Ohio. The da include only pairs in which the color phase of both parents was know Percentages are in parentheses.*

Category	Red	Intermediate	Gray	Total
		1944-73		
Breeding population	81 (16.1)	13 (2.6)	408 (81.3)	502 (100.0
Offspring	126 (15.3)	19 (2.3)	681 (82.4)	826 (100.0
Totals				
Including intermediates	207 (15.6)	32 (2.4)	1,089 (82.0)	1,328 (100.0
Excluding intermediates	207 (16.0)	—	1,089 (84.0)	1,296 (100.0
		1952-73		
Breeding population	62 (15.4)	12 (3.0)	328 (81.6)	402 (100.0
Offspring	91 (14.1)	17 (2.6)	536 (83.2)	644 (99.9
Totals				
Including intermediates	153 (14.6)	29 (2.8)	864 (82.6)	1,046 (100.0
Excluding intermediates	153 (15.0)	—	864 (85.0)	1,017 (100.0

enetic Hypotheses

Hrubant (1955) analyzed screech owl data by the gene frequency ethod to test whether the matings occurred at random, and ıether the offspring were produced in agreement with any of veral genetic hypotheses. The genetic hypotheses tested ere: (1) one pair of genes with dominance, (2) one pair of genes thout dominance, (3) multiple alleles, and (4) sex associated heritance. He concluded that lack of dominance may be smissed as an acceptable mode of inheritance since neither of the ays in which this mode could be applied could account for the stribution of colors of the young produced and that none of the x-associated modes are acceptable since the two attributes, color ıd sex, are independent of each other. This left Hrubant (1955) th but two modes of inheritance as possible explanations of the served data. In testing the assumption of simple dominance, it as noted that red by red produce only red. Some grays were pected, but the lack of grays may be attributed to the small mple analyzed (only 10 offspring). Under the hypothesis of ultiple alleles, the observed value of the intermediate class from d by gray matings deviated from the hypothetical value by a gnificant amount; however, small samples (only 10 offspring om red by red and 55 offspring from red by gray) made Hrubant's ıdings somewhat inconclusive.

ne Pair of Genes with Dominance

Using the same approach as Hrubant, but with considerably rger sample sizes, we again tested the hypothesis of simple minance. The method requires the assumption that the population is in equilibrium with respect to mating type, phenotype, and notype. The significant change in color phase ratios between 51 and 1952 suggested that the data collected during the first 8 yr the study (1944–51) should not be pooled with the latter data. ıerefore, genetic hypotheses were tested with information llected during the last 22 yr of the study (1952–73). To test this pothesis the owls may be classified merely as red or gray, and the fference assumed to be caused by one pair of genes with the gene r red exhibiting dominance over the gene for gray. The termediate owls may be regarded as misclassified gradations of e red and gray. Removal of the intermediates from the sample tal in Table 23 leaves 864 gray and 153 red owls. Since an erwhelming number of the matings were gray by gray (Table 24), ıd since these matings produced only gray offspring, the gray ıenotype may be assumed to be due to the recessive gene, and red ıe to its dominant allele.

Table 24. *Mating types of progeny of screech owls in northern Ohio with respect t color, 1952–73.*

Mating type adult	**Number of successful matings**	**Progeny**		
		Red	**Inter.**	**Gray**
1. Red × red	8	23	0	5
2. Red × gray	46	68	1	63
3. Red × Inter.	0	0	0	0
4. Inter. × Inter.	0	0	0	0
5. Inter. × gray	12	0	16	29
6. Gray × gray	135	0	0	439
Totals	201	91	17	536

Let R stand for the dominant gene for red pigment and r stand fo its recessive allele for gray pigment. Let p be the frequency of r i the sample, such that p + q = 1. Values of q and p may be obtaine from the sample so that they are the maximum likelihood estimate of θ and 1–θ, the true frequencies of r and R in the population.

Following the discussion by Hrubant (1955), the estimates ma be based upon the parents only, the offspring only, or upon th entire sample of 1,017 owls, omitting the intermediates. The entir sample of 1,017 appears to be the best choice since there is n marked evidences of heterogeneity within it and since the parent and offspring contain about the same frequencies of red and gra owls. Of 1,017 owls in the entire sample (omitting intermediates 864 were gray. The frequency of r thus $q = \sqrt{864/1,017} = 0.921$ and of R is $p = 0.0783$.

The theoretical mating type frequency, determined by th expansion of the binomial $((1-\theta) + \theta)^4$ using $q = 0.9217$ as a estimate of θ, and the observed mating frequencies are compared i Table 25. The data in this table show that the various kinds c matings occurred with frequencies in agreement with thos expected if mating is at random. The computed chi-square i smaller (3.30) than the critical (5.99) at the 5% level of significanc of 2 degrees of freedom.

Table 25. *Testing specific mating types of screech owls under hypothesis of one pair of genes with dominance.*

Mating type	Theoretical frequency	Expected proportions		Expected frequency	Observed frequency
1. Red × red RR × RR	$(1-\theta)^4$	0.00004	0.02264	4.3	8
2. Red × red RR × Rr	$4\theta(1-\theta)^3$	0.00177			
3. Red × red Rr × Rr	$4(\theta)^2\ (1-\theta)^2$	0.02083			
4. Red × gray RR × rr	$2(\theta)^2\ (1-\theta)^2$	0.01042	0.25566	48.3	46
5. Red × gray Rr × rr	$4(\theta)^3\ (1-\theta)$	0.24524			
6. Gray × gray rr × rr	$(\theta)^4$	0.72170	0.72170	136.4	135
			1.00000	189.0	189

$X^2 = 3.30$, 2 d.f.

Table 26 contains the test of the observed distribution of young produced by individual mating types compared to their expected distribution. The expected numbers of offspring are found from the relative frequencies of the matings given in Table 25. The data show that in all three mating combinations the observed numbers of offspring occur with frequencies in agreement with those calculated if the difference betwen red and gray is due to only one pair of genes with red dominant to gray. In fact, the observed and expected frequencies for red by gray and gray by gray are in complete agreement, whereas the red by red pairings are in nearly complete agreement (chi-square 0.22). The critical level for rejection of the hypothesis is 3.84 at the 5% level of significance for 1 degree of freedom. The observed data are nearly a perfect fit.

Table 26. *Distribution of young screech owls produced by mating phenoty under hypothesis of one pair of genes with dominance.*

Mating	Observed number offspring		Expected number offspring		
	Red	Gray	Red	Gray	X^2
1-3 Red × red	23	5	21.6	6.4	0.22
4-5 Red × gray	68	63	68.2	62.8	—
6 Gray × gray	0	439	0	439.0	—

Multiple Alleles

The other possible mode of inheritance (Hrubant 1955) is multiple allelic system. Assume the red, intermediate, and gr phenotypes are inherited in this manner with a graded order dominance of Y (red) dominant to y′ (intermediate) dominant t (gray). Table 27 illustrates the observed and expected sam frequencies and theoretical population frequencies used in derivi the values for the statistics r = 0.0760, s = 0.0152, and t = 0.90 as estimates of the true frequencies of genes.

Table 27. *Sample frequencies and estimates of population gene frequencies screech owls under hypothesis of a system of multiple alleles.*

Genotype		Theoretical frequency	Observed frequency	Expected frequency
YY		p^2		0.0058
Yy′	Red	$2p\sigma$	0.146	0.0023
Yy		$2p\gamma$		0.1381
y′y′		σ^2		0.0002
	Inter.		0.028	
y′y		$2\sigma\gamma$		0.0276
yy	Gray	γ^2	0.826	0.8259

$t= \sqrt{864/1046}$ =0.9088, frequency of y

$s= \sqrt{864+29/1046}-0.9088$=0.0152, frequency of y

$r= 1-(t+s)$ =0.0760, frequency of Y

The theoretical mating type frequency determined by the xpansion of the trinomial $(p + \sigma + \gamma)^4$ and the observed mating ype frequencies are compared in Table 28. The data in this table how that the various kinds of matings occurred with frequencies n agreement with those expected if mating is at random. The omputed chi-square (5.99) is smaller than the critical (11.07) at the % level of significance for 5 degrees of freedom; therefore, we oncluded that the matings were at random.

able 28. *Testing specific mating types of screech owls under hypothesis of a system of multiple alleles.*

Mating type by phenotypes	Theoretical frequency	Expected proportions	Expected frequency	Observed frequency
Red × red	$p^4+4p^3\sigma+4p^3\gamma+4p^2\sigma^2+8p^2\sigma\gamma+4p^2\gamma^2$	0.0213	4.3	8
Red × gray	$2p^2\gamma^2+4p\sigma\gamma^2+4p\gamma^3$	0.2415	48.5	46
Red × inter.	$2p^2\sigma^2+4p\sigma^3+12p\sigma^2\gamma+4p^2\sigma\gamma+8p\sigma\gamma^2$	0.0081	1.6	0
Inter. × inter.	$\sigma^4+4\sigma^3\gamma+4\sigma^2\gamma^2$	0.0008	0.2	0
Inter. × gray	$2\sigma^2\gamma^2+4\sigma\gamma^3$	0.0460	9.2	12
Gray × gray	γ^4	0.6821	137.1	135
		0.9998	200.9	201
			$X^2 = 5.99$, 5 d.f.	

The observed distribution of young produced by the specific henotypic mating types as compared to their expected distribuon is shown in Table 29. The data show agreement in all cases etween the frequencies of the observed numbers of offspring and ose calculated if the difference between red, intermediate, and ray were due to a multiple allelic genetic system. This system volves a graded order of dominance of red over intermediate over ray.

Table 29. *Distribution of young screech owls produced by mating phenotyp under hypothesis of a system of multiple alleles.*

	Observed numbers offspring			Expected numbers offspring			
Mating	Red	Inter.	Gray	Red	Inter.	Gray	X
1. Red × red	23	0	5	21.3	0.1	6.6	0.
2. Red × gray	68	1	63	68.6	1.1	62.3	0.
3. Red × inter.	—	—	—	—	—	—	—
4. Inter. × inter.	—	—	—	—	—	—	—
5. Inter. × gray.	0	16	29	0	22.3	22.7	3.
6. Gray × gray	0	0	439	0	0	439.0	—

Unfortunately then, neither of the two hypotheses of gene action (one pair of genes with dominance and multiple alleles) that appeared satisfactory to Hrubant (1955) can be eliminated on the basis of breeding data presented here. In fact, the evidence for the two hypotheses was strengthened by the new data as the expected values were in nearly perfect agreement with the observed breeding data. The fact that red by red produced approximately 25% grays was a most important finding because Hrubant noted that red by red produced only reds in his small sample. Therefore, the following hypotheses remain for the gene action: (1) If the intermediate phenotype is assumed to be due to genetic modifiers, the difference between red and gray is due to one pair of alleles, the gene for red exhibiting dominance over its allele for gray; (2) if all three colors are considered, the colors are inherited on the basis of a series of three alleles with a graded order of dominance of red → intermediate → gray.

Brood Size and Color Phase

Data were insufficient to provide a fledging rate estimate (per nesting attempt) for each color phase; however, a pooled estimate of the number of young fledged per successful nest was obtained. The color phase of both parents was documented for 211 successful nesting attempts during 1944–72 (Table 30). The data for 1973 were not included because one egg was taken from each nest for pesticide analysis. No significant difference in the number of young fledged for the various breeding combinations could be detected.

Table 30. *A summary of the estimated number of young screech owls fledged per successful nest for the various combinations of color phase pairs, 1944-72.*

Category	Young fledged 1	2	3	4	5	6	Number nests	Young fledged per successful nest	95% C.I.
Gray × gray	18	7	35	49	30	8	147	3.61	3.39-3.83
Gray × red	1	5	8	15	13	1	43	3.86	3.52-4.20
Red × red	1	0	1	4	3	0	9	3.89	3.06-4.72
Inter. × gray	1	0	1	5	3	1	11	4.09	3.32-4.86
Inter. × red	0	0	0	1	0	0	1	4.00	—
Total	21	12	45	74	49	10	211	3.70	

STATUS OF POPULATION

The status of any wildlife population may be evaluated in three general ways: (1) a complete count or direct enumeration on an annual basis, (2) an index to abundance at some time period during the life cycle, or (3) a life-equation approach which provides an indirect evaluation of the population's condition. These approaches are not new and fall within the general outline presented by Leopold (1933:139): "(1) *Census* (Measuring the Stock on Hand), and (2) *Measuring the Productivity* of the stock and comparing it with a standard." Furthermore, it is always useful to compare results obtained from several approaches. The complete count or direct enumeration of screech owls is impossible due to their habitat preferences. Therefore, we will rely upon an index to annual abundance and the life-equation approach to evaluate the status of the screech owl population in northern Ohio.

ndex to Annual Abundance

The occupancy rate of wood duck boxes by screech owls during he nesting season may provide some insight into the relative nnual abundance of the species on the study area. However, since he nest boxes were always placed in suitable habitat and loss of habitat has occurred on the study area (Table 1), the occupancy rate or nest boxes would provide only an index to abundance in uitable habitat. Thus, the possibility of an undetected decline due o loss of habitat exists. To further complicate the matter, we have een forced to use an index to annual abundance based on uccessful nests. This modification was necessary because during some years the boxes were visited early in the nesting season (chance to observe nests that were later abandoned and u successful), whereas in other years nests were visited only banding time (successful nests only recorded). Therefore, becaus of the fluctuations in annual effort we believe that a more realisti annual comparison of abundance would be obtained fro successful nests only.

Although indices based on wood duck box usage have man potential biases, two factors present during this study tend t minimize these biases: (1) the same observer checked the boxe annually, and (2) approximately the same number of boxes wer available each year.

The information collected during the 30-yr period suggested n long-term trend in abundance in suitable habitat, as measured b numbers of successful nests (Table 31). The 4 yr (1952–55) whe students assisted in the study could not be evaluated because th number of nests checked was unknown. Excluding those 4 yr, th 10-yr indices to abundance were as follows: 1944–51, 10. 1956–63, 8.4; and 1964–73, 9.0. Successfully nesting screech owl were found annually in approximately 8.9% of the nest boxe during the 30-yr study. Assuming that 69.2% of the screech ow nesting attempts were successful (see section on BREEDIN BIOLOGY), another 4.0% of the nest boxes were used annually, bu without success, making a total of about 12.9% of the boxes utilize annually during the study.

Table 31. *An index to the abundance of screech owls in suitable habitat in northern Ohio, 1944-73.*

Year[a]	No. of boxes checked	No. of successful nests	Percent with successful nests
1944	45	4	9
1945	78	4	5
1946	95	6	6
1947	128	14	11
1948	133	11	8
1949	139	15	11
1950	140	24	17
1951	145	10	7
Total 1944-1951	903	88	10.1[b]
1956	210	20	10
1957	208	14	7
1958	190	14	7
1959	180	12	7
1960	155	11	7
1961	140	9	6
1962	130	18	14
1963	125	11	9
Total 1956-63	1,338	109	8.4[b]
1964	125	9	7
1965	135	7	5
1966	130	9	7
1967	130	16	12
1968	130	13	10
1969	130	10	8
1970	130	12	9
1971	130	11	8
1972	135	16	12
1973	153	19	12
Total 1964-73	1,328	122	9.0[b]
Total 1944-73	3,569	319	8.9[b]

[a] Numbers of boxes checked in 1952-55 are unknown.
[b] Each year given equal weight.

Life Equation Approach

A mathematical model showing the relations between popul tion parameters that yield stable populations was developed b Henny et al. (1970). Information needed for the model includes (mortality rate schedules (obtained from recoveries of bande birds), (2) recruitment rates, and (3) age at sexual maturit Estimates of these parameters have been presented in this pap for the screech owl.

We know that screech owls are capable of breeding at the end their first year of life (as 1-yr-olds), although the percentage in th age class that breeds is not known with certainty. However, we sti believe that the excercise in constructing a life-equation model worthwhile, because it will point out future research needs and a as a check on the internal consistency of the input data. Adu mortality rate estimates for the screech owl range from 32.8 t 39.0% (Table 15), with a pooled estimate of 33.9%. The mortality ra estimate for the first year of life was 69.5% (Table 15). The observe recruitment rate per breeding pair was estimated at between 2.5 (Table 13) and 2.63 based on the exposure-day method.

Initially, let us assume that all screech owls breed as 1-yr-old although we have some evidence that a portion of the 1-yr-olds d not nest. The estimated number of young that must be fledged p breeding-age pair to maintain a stable population may b estimated by the following formula (from Henny 1972):

$$\overline{m} = \frac{1 - s}{s_0 \, (1 - s + s_1)}$$

where

$\overline{m}$ = the average number of female fledglings produced pe breeding-age female ($2\overline{m}$ = the total number of youn produced per breeding female assuming an equal sex ratio o fledglings)

s = third year and later survival rate

s_0 = first year survival rate

s_1 = second year survival rate

By using the pooled estimate for adult mortality and assuming tha all 1-yr-olds attempt to nest, it is estimated that only 2.22 young ar required per breeding pair to maintain a stable population. This i slightly less than the observed recruitment (2.55 to 2.63), and although the mortality rates may not be precise, the modeling approach suggests that not all 1-yr-old screech owls need to attemp o nest annually in order to maintain a stable population. To pursue his matter a little further, let us assume for the moment that the ecruitment rates and the mortality rates are correct and, through he modeling process, let us calculate the percentage of 1-yr-olds solve for p_1) that must attempt to nest annually to balance the life quation (see Equation 1 in Henny 1972:6). Given the above onstraints and assuming that 2-yr-olds and older attempt to nest ach year, the population could remain stable if at least an average f 60% of the 1-yr-olds nested annually. This estimate is in farily lose agreement with the 77 to 83% estimate based on a small ample of field data which may be biased upward.

Summary of Status

In summary, we believe that the screech owl population in northern Ohio has fluctuated in abundance during the last 30 yr, with no long-term trend being apparent in suitable habitat (Table 31). In addition, the recruitment rate observed during the long-term study seemed to be adequate to maintain the population numbers. We have indirect evidence that all 1-yr-olds are not required to nest (from modeling approach) and field evidence suggesting that a sufficient percentage of 1-yr-olds are nesting. Furthermore, we have no evidence of eggshell thinning in the population (Table 17), although laboratory tests have shown that the species is susceptible to the eggshell thinning phenomenon. Residue levels of DDT and its metabolites along with PCB's were low (Table 18). It should be cautioned, however, that even though screech owls seem to be adaptable to people and their structures, continued habitat loss may gradually reduce the population numbers in northern Ohio as the woodlots and creek bottoms become cleared and farmed more intensively. The forested lands in the four-county study decreased 12% between 1958 and 1967.

SUMMARY

1. The life history and population ecology of the screech owl wa studied in northern Ohio between 1944 and 1973. The owl nested in boxes established for wood ducks. The birds wer banded and periodically recaptured. Food habits, productivit information, and color phase of the parent birds and offsprin were recorded.
2. The screech owl is an opportunistic feeder. The diet change with the seasons of the year, i.e., during the nesting season migrant birds replace mammals in importance, and during th late summer insects become important.
3. There is no evidence from banding data to suggest that screech owls in the northeastern United States migrate.
4. Young screech owls begin dispersing from their natal areas in late summer or early fall, with only about one-fourth of th young birds remaining within 10 km (6 mi) of the banding site On the contrary, adult birds remain close to the area where they previously nested.
5. The hypothesis of random dispersal distance in young screech owls was rejected. There appear to be two groups in the population: (1) a group showing little dispersal, and (2) a group wandering considerable distances.
6. The directional pattern of dispersal was random.
7. Pairs of screech owls were noted in the nest boxes in early February, but egg laying did not peak until about 15 March Hatching takes place in mid-April to early May and most of the young leave the nest the last week of May or the first week in June.
8. The mean clutch size was 4.43 with a mean of 3.80 young fledged per *successful* nest. An estimated 69.2% of the nesting attempts were successful. Including unsuccessful nesting attempts, an estimated 2.55 to 2.63 young were fledged per *breeding pair.*
9. Annual variation in the number of young fledged per successful nest was small. The lack of variability was probably due to the predictable food source of passerine birds that migrated through the area each spring when young were in the nest. This contrasts with the highly variable productivity reported for owls dependent upon local cyclic rodent populations.

0. Raccoon predation was implicated in a number of unsuccessful nesting attempts, but the overall effect of the raccoon on the screech owl population was not fully assessed.
1. The sex ratio in the population did not differ significantly from a 50:50 ratio.
2. The first year mortality rate of the screech owl was estimated at 69.5%; adult mortality was estimated at 33.9%.
3. Male and female screech owls banded as nestlings were known to nest successfully at the end of their first year of life (as 1-yr-olds). Two estimates of the average proportion of 1-yr-olds nesting ranged from 77 to 83%, but the percentage may be lower.
4. No significant eggshell thinning was detected in the population in 1973, and residue levels of DDE and PCB's were low.
5. In northern Ohio, the screech owl population consists mainly of a gray- and red-phased birds, but about 2 to 3% of the birds are intermediate in color.
6. A significant change in the ratio of red- to gray-phased birds occurred in December 1951. This change coincided with the lowest temperatures during the 30-yr study and the heaviest snowfall. The red-phased birds decreased from 23.3% of the population to 14.7%. Additional evidence from retrap information suggests that the grays survived much better than the reds during the stressful period. The ratio of reds in the population failed to increase to pre-1951 levels during the next 20 yr.
7. No significant relationship existed between sex and color phase in our sample of 760 nesting screech owls.
8. The following hypotheses of gene action remain: (1) If the intermediate phenotype is assumed to be due to genetic modifiers, the difference between red and gray is due to one pair of alleles, the gene for red exhibiting dominance over its allele for gray; or (2) if all three colors are considered, the colors are inherited on the basis of a series of three alleles with a graded order of dominance of red → intermediate → gray.
9. No significant difference in brood size and color phase of the parents could be detected.
0. An index to annual abundance suggests that the screech owl population fluctuated in northern Ohio during the last 30 yr, but with no long-term trend apparent in available habitat. The life-equation approach also suggests that, over the long term, productivity probably balanced mortality.

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A LOOK AT ITS PAST AND FUTURE

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NUMBER 72

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FISH AND WILDLIFE SERVICE

NORTH AMERICAN FAUNA

This publication series includes monographs and other reports of scientific vestigations relating to birds, mammals, reptiles, and amphibians, for professio readers. It is a continuation by the Fish and Wildlife Service of the series begun 1889 by the Division of Ornithology and Mammalogy (Department of Agricultu and continued by succeeding bureaus—Biological Survey and the Bureau of Sp Fisheries and Wildlife. The Service distributes these reports to official agencies, to braries, and to researchers in fields related to the Service's work; additional cop may usually be purchased from the Division of Public Documents, U.S. Governme Printing Office.

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by Sanford R. Wilbur

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The California Condor, 1966-76: A Look at its Past and Future

by

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Laurel, Maryland 20811

Abstract

The California condor (*Gymnogyps californianus*) was studied on about 900 field days between 1966 and 1976. In addition, some 1,000 items of literature, specimen records from 56 museums, and 3,500 reports of condor sitings by cooperators were analyzed. Distribution does not appear to have changed significantly since the 1930's, although there are some areas within the species' range that have become unusable. Two subpopulations of condors exist, one occupying the Coast Range Mountains, and the other found in the Transverse Ranges, Tehachapi Mountains, and Sierra Nevadas. There are well-defined seasonal movements within each subpopulation area. The surviving, wild population was estimated to be 45 condors in 1976, a decline of about 20% since 1965 and probably over 50% since 1940. No reliable population estimates are available before the 1940's, but it appears that a major decline occurred between 1880 and 1920. Shooting and specimen collecting were the primary causes of the early decline, and shooting continued as a major problem into the 1960's. Recent declines are a result of inadequate production; annual surveys indicate that only 16 young have been produced since 1968. Causes of low production are unknown but inadequate food supply, environmental contaminants, and disturbance from air traffic and petroleum extraction are implicated. A recovery plan for the condor is in operation; steps have been taken to supplement food supplies, preserve nesting and roosting habitat, and protect surviving birds from man-caused mortality or disturbance. The condor's prospects of recovery in its natural habitat seem bleak; a captive propagation program is proposed to supplement wild production.

←

Frontispiece. California condors in Sespe Condor Sanctuary. (Photo by Fred Sibley)

Between 1939 and 1946, the National Audubon Society sponsored a study by Carl B. Koford of the breeding biology of the California condor (*Gymnogyps californianus*). His field work was concentrated on one condor nesting area in Ventura County, California. Library research into the history of the condor population, and occasional trips into other parts of the condor range, allowed him to publish a general overview of the species' history and status along with his observations of nesting behavior (Koford 1953).

Koford's work was followed in 1963-64 by a second National Audubon Society study, a short-term assessment of changes in the California condor population since 1946 (Miller et al. 1965). These researchers concluded that there had been a one-third decrease in the size of the population since Koford's study. Additional research into the causes of the decline seemed highly desirable, and following the establishment of the Patuxent Wildlife Research Center's Endangered Wildlife Research Program in 1965, a U.S. Fish and Wildlife Service researcher, Fred C. Sibley, was assigned to renew investigations of this species. He studied various aspects of life history and ecology, specifically concentrating on the effects of man-caused disturbances on nesting condors. After November 1969, I continued the research begun by Sibley, with special emphasis on condor food supplies and on factors inhibiting reproduction. This publication contains the result of our combined research.

Study Methods

Information presented in this report was derived from review of approximately 1,000 items of literature relating to the California condor and other aspects of avian biology, specimen records and field notes from 56 museums and private collections, about 3,500 condor observation reports from several hundred part-time cooperators, and the personal field work of Fred Sibley and myself.

Altogether, Sibley and I spent approximately 900 days in the field on condor research. Sixty percent of our time was spent in condor nesting areas, 17% in summer roosting areas, and 23% in condor feeding areas. During 1966-69, nesting studies absorbed 66% of field time, with the remaining effort divided between feeding and roosting area studies. In 1970-76, 56% of my field time was spent in nesting areas, 31% in feeding areas, and 13% in roosting habitat. Ten percent of total field time was spent on investigations in the Coast Range Mountains; most of the remaining time was spent in Ventura, Los Angeles, Kern, and Tulare counties.

Cooperators reported from all sections of the condor range, but coverage varied seasonally and geographically. Two-thirds of cooperator reports were for the period between June and October, when more people are in the field and back-country areas are generally more accessible. Also, condors are more conspicuous in summer and early fall because they are congregated in larger flocks in more accessible areas than at other seasons.

About 15% of cooperator reports are of condors in the Coast Ranges, 35% of birds in the Sierra Nevada and Tehachapi Mountains, and the remainder

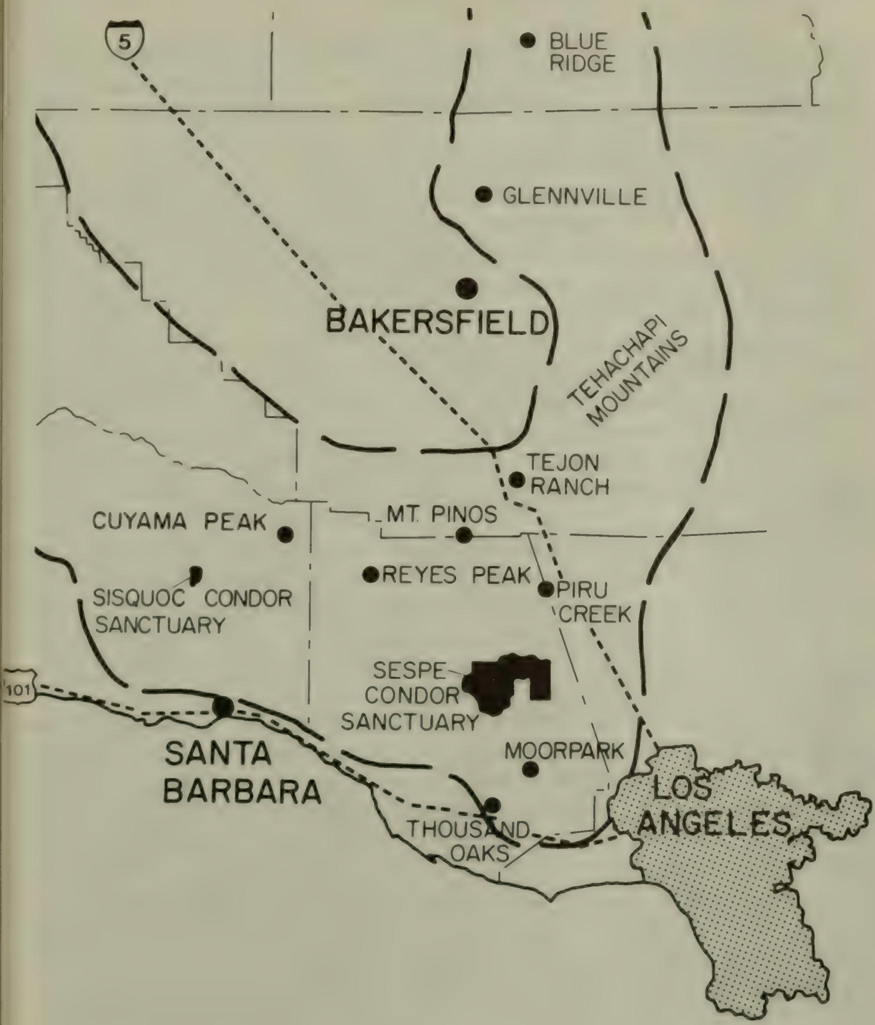

Fig. 1. Locations of frequent observation points of California condor.

in Ventura and Los Angeles counties. Areas of frequent condor observations are shown in Fig. 1.

I have attempted to compare present-day condor numbers, production, and distribution with those of earlier time periods, but I recognize that this can be done only in a general way. Our research emphasis has been different than that of earlier studies; we have had a much larger group of cooperators reporting to us, and access into the condor range is now much quicker and easier than before. Also, reduction in total available habitat has changed condor distribution somewhat, and may have influenced flocking and migration patterns.

Species Characteristics

A detailed account of California condor behavior and life history is included in Koford's (1953) monograph on the species, so it is unnecessary to repeat this information. A general survey of the condor's basic characteristics, however, will help put later sections of this report in perspective.

The condor is a representative of the New World vultures, family Cathartidae, which are traditionally classified with eagles, hawks, falcons, and related birds (order Falconiformes). Some recent investigators (especially Ligon 1967) presented good morphological and behavioral evidence that New World vultures may actually be as closely related to the storks, family Ciconiidae, as they are to hawks and eagles (Fig. 2).

California condors weigh approximately 9 kg (20 pounds) and have an average wingspread of 3 m (9 feet). They do not attain adult plumage until 6 years of age. Because no immature-plumaged condors have ever been reported as part of a breeding pair, it is assumed that they do not reproduce until at least their 6th year. Condors in captivity have lived to be 35 to 45 years old, but the average longevity of wild condors is thought to be about 20 years.

Although not proven, condors likely stay with the same mate as long as both survive. The clutch is limited to one egg, laid between February and May in a cave or rock crevice; length of incubation is unknown. Koford (1953) reported one egg incubated a minimum of 42 days. In captivity, the egg of the Andean condor (*Vultur gryphus*) has required 54 to 61 days to hatch (Lint 1959; Olivares 1963; Dekker 1967).

The young bird is confined to the nest cave for about 20 weeks, and remains essentially flightless near the nest for another 10 weeks. Even after fledging, the immature condor is dependent on the parents for a number of months. Because the entire reproductive cycle may take longer than 12 months, most condors have been thought to nest biennially. Nevertheless, it now appears that condors may under some circumstances breed in consecutive years. Conversely, several species of long-lived birds are known to breed less regularly than is biologically possible (Broley 1947; Wynne-Edwards 1962), so the "normal" nesting interval for the California condor may be longer than every other year.

California Condor Habitat

Condors occupy a wishbone-shaped portion of California extending from Santa Clara County (rarely San Mateo County) south to Ventura County, then north to Fresno County (Fig. 3). This area corresponds roughly with the mountainous terrain surrounding the San Joaquin Valley: the Coast Ranges on the west, Transverse and Tehachapi Mountains at the south, and the Sierra Nevada on the east (Durrenberger 1965). Because the condor is a soaring bird, it depends to some extent on thermal updrafts and wind currents of mountain terrain for transport (Koford 1953:50). Historically, however, condors traveled far out over the almost flat Central Valley, as much as 65 km (40 miles) from foothill areas (Belding 1879; Stillman 1967). Recent re-

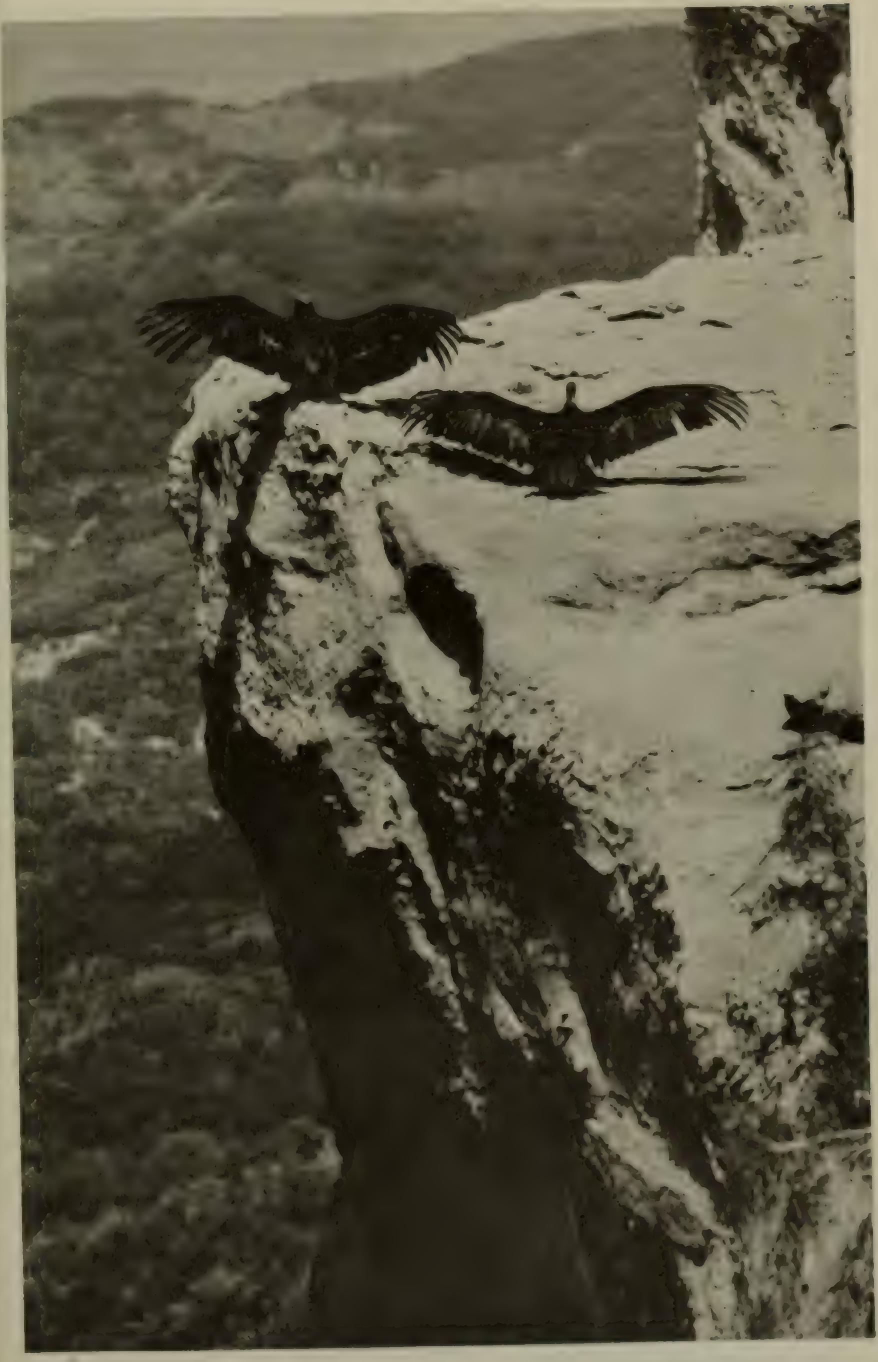

Fig. 2. Adult and immature condor in spread-wing posture, a behavior pattern shared with the storks. (Photo by Fred Sibley)

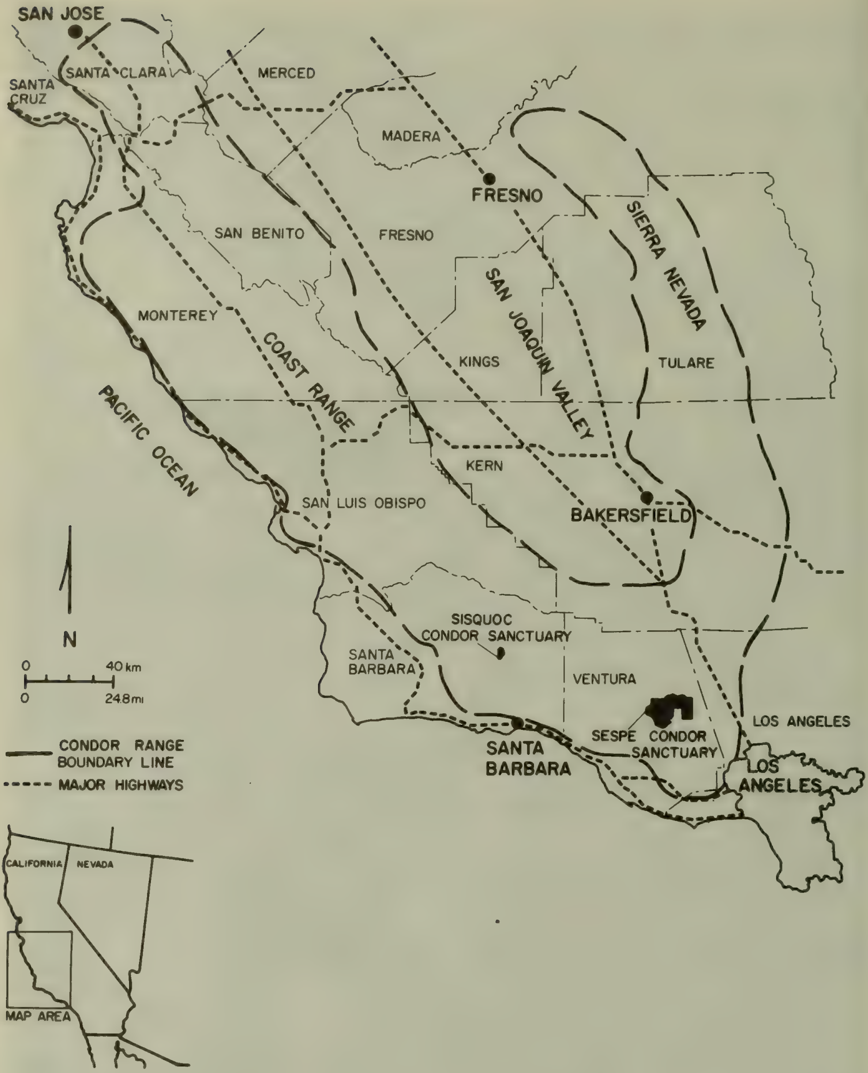

Fig. 3. Principal range of the California condor, 1966-1976.

striction to the more mountainous areas of the State is to a great extent a function of habitat availability. The San Joaquin Valley, formerly grassland with herds of native big game and domestic livestock, is now predominantly intensively managed cropland. The Los Angeles metropolitan area, with some 10 million inhabitants (Dooley et al. 1975), extends along the south boundary of the condor range for 150 km (90 miles) east and west, and 75 km (45 miles) north and south. Similarly, the San Francisco Bay area, with 4 million inhabitants and 7,400 km^2 (2,900 square miles) of urbanization and industrialization (Dooley et al. 1975), forms a barrier to the north.

Although downtown Los Angeles is less than 75 km (45 miles) from the principal condor nesting areas in Ventura County, the condor range itself is sparsely populated and, with only a few exceptions, receives limited human use. Thirty-six percent (1.7 ha) is in public ownership, principally administered by the U.S. Forest Service (Rieger 1973). Much of the 2.8 million ha (6.9 million acres) of privately owned lands is in large holdings. The largest single holding, The Tejon Ranch in the Tehachapi Mountains, includes 117,000 ha (290,000 acres), much of it open livestock range.

Climate.—The climate of the condor range is semi-arid, with 25 to 75 cm (10-30 inches) precipitation, falling mainly as rain between November and May. Snowfalls are usually light and of short duration. No rain falls over much of the area in summer and early fall. Annual temperatures vary from 0 to 43 C. One-half or more of the days during the year are essentially cloudless (Durrenberger 1965).

Geography.—Most condor habitat is located between 300 and 2,700 m (1,000-9,000 feet) elevation. This includes all of the Coast Range and Tehachapi Mountains, but only the western slopes of the Sierra Nevada. Distance from food sources may preclude regular use of higher elevations.

Condor nesting occurs in the area 610 to 1,372 m (2,000-4,500 feet) above sea level. The nesting areas are characterized by extremely steep, rugged terrain, with dense brush surrounding high sandstone cliffs. Principal plant species are several types of *Ceanothus*, live oaks (*Quercus* sp.), chamise (*Adenostoma fasiculatum*), silk tassel bush (*Garrya* sp.), and poison oak (*Rhus diversiloba*). Interspersed with the brush are small groves of bigcone Douglas-fir (*Pseudotsuga macrocarpa*), which are favored roosting areas for condors. The cliffs have numerous crevices and wind- and water-created caves in which condors lay their eggs.

Within the brushland (chaparral) community, there are small openings (potreros) dominated by annual grasses. In the Coast Ranges, through the Tehachapi Mountains, and in the foothills of the Sierra Nevada are vast areas of open grassland dominated by introduced annual grasses, particularly wild oats (*Avena fatua*) and cheatgrass (*Bromus tectorum*). Some stretches are almost treeless; others have scatterings of oaks (*Quercus* sp.), walnuts (*Juglans californica*), and related trees. In these open areas occupied by domestic livestock, condors find most of their food supply. Although all nesting sites are within the Los Padres National Forest, almost all condor feeding areas are privately owned.

In the higher portions of the Transverse Ranges, and above about 1,800 m (6,000 feet) in the Sierra Nevada, are stands of several species of conifers. These forest areas are occupied by nonbreeding condors as summer roosting sites, and the open rangelands below provide food for them.

Distribution

General Distribution, 1966-76

Within the range of the California condor, there are well-defined seasonal movements and use areas.

January.—Most condors are in the Sespe Creek-Piru Creek area of Ventura and western Los Angeles counties, and in the Tejon Ranch area of southern Kern County. Flocks in those areas sometimes include 10-15 condors, although the more usual group is about 4 birds.

Elsewhere, condors range widely through the Coast Ranges from the southern San Francisco Bay area south through Santa Barbara County; most sightings there are of individuals or pairs. Less regularly, individuals and small groups inhabit northern Kern and southern Tulare Counties.

February.—Most sightings occur in the vicinity of the Sespe Condor Sanctuary, and because the number of observations and flock sizes are similar to those in January, I think that the Tejon Ranch continues to harbor a large share of the population. Snow cover and poor road conditions preclude regular surveys in that area.

Distribution in the Coast Ranges is similar to January. Use of northern Kern and Tulare counties increases, and condors occasionally range even farther north in the Sierra Nevada foothills.

March.—Distribution in March is similar to February, although flock size in the Sespe area usually increases.

April.—Flock size in the Sespe area decreases as more condors move into Kern and Tulare counties. Kern and Tulare condors are apparently nonbreeding condors beginning a northerly movement away from the Sespe-Piru breeding region.

Coast Range distribution remains the same.

May.—The general trend in May is continued dispersal as singles, pairs, and small groups (three to five birds), although some flocks of six to eight condors are occasionally seen in the Sespe-Piru region in May. Sightings become more numerous in the Sierra Nevada foothills of Tulare County. Coast Range distribution remains unchanged.

June.—Populations in the Sespe-Piru region continue to decline, and most sightings and largest groupings are found in Tulare County. Flocks of 8-12 condors are seen, but it is more common to see 5 or less together. Coast Range distribution remains constant.

July.—The Sespe-Piru population is limited to a few scattered breeding pairs. Most condors inhabit Tulare and northern Kern Counties. In some years, perhaps because of food supply, a substantial population occupies the Mt. Pinos area on the Kern-Ventura County border. Flock size increases in July, and groups of 5-10 are seen.

August.—Condor use of the Coast Ranges and the Sespe-Piru area remains light, as most birds are in Kern and Tulare counties. Individual flock size reaches a peak in August and early September. Sightings of more than 10 condors together are common, and there are six records of 20 or more condors in a group during this study.

September.—In most years the majority of condors have moved south from Tulare County, although occasionally some large groups remain. Peak numbers are in northern Kern County in early September, then the birds begin a gradual movement southward into the Tejon Ranch area.

October.—Condors may be found in any part of their total range in October, but the majority are always found in the Tehachapi Mountains on and near the Tejon Ranch. Groups of 10-20 are regularly seen, and more than 50% of the total condor population is found in that area.

November-December.—Distribution is similar to that of October, with more use shifting back into the Sespe-Piru region as winter progresses.

Sightings outside the range depicted in Fig. 3 may involve occasional vagrant birds wandering from their usual habitat. However, based on 15 records (most so far unconfirmed) from western San Bernardino and Riverside counties, I suspect that a few condors regularly use that region, at least during summer and fall.

Eight unconfirmed sightings in the Sierra Nevada foothills north of Fresno County suggest that some condors inhabit Madera and Mariposa counties, and perhaps even farther north, in some years. Although rumors of condors in the Sierra San Pedro Martir, Baja California, continue to be heard, it now appears unlikely that there is a resident population there (Kiff 1977).

Subpopulations of California Condor

The regularity with which condors are observed in certain areas at specific times of year, and in relatively predictable numbers, indicates that at least two subpopulations of condors exist (Fig. 4). The division in the population occurs near the Santa Barbara-Ventura County line. On the Coast Range (western) side of this line since 1966, I have only five records of four or more condors together; the highest count was only five condors (Appendix I). The highest possible composite counts (condors sighted at locations far enough apart to be different birds) during this period do not indicate more than 10-11 condors in the entire Coast Range area. As will be discussed later, nesting habitat in this region appears adequate for a considerably larger population, and food supply seems greater and more dependable than in the Sespe-Piru area. If there is free interchange between Coast Range and Sespe condors, it seems likely that greater use would be made of the Coast Range area.

Subpopulations are well known in other avian species. Common terns (*Sterna hirundo*) form individual cohesive groups that are self-sustaining and relatively free from association with other groups. Some colonies only a few miles apart are almost completely unrelated to one another (Austin 1951).

Herring gulls (*Larus argentatus*) segregate into subgroups for nesting and feeding (Drury and Nisbet 1972), and pink-footed geese (*Anser brachyrhynchus*) "form closed groups occupying small, well-defined areas" in which "the scale of mixing is negligible" (Boyd 1972). Although not always thoroughly studied, the high degree of "homing" to specific areas and nest sites shown by such diverse groups and species as waterfowl (Sowls 1955; Hochbaum 1955), common crows (*Corvus brachyrhynchos*; Emlen 1940), ravens (*Corvus corax*; Cushing 1941), eagles (Broley 1947; Brown 1972), and peregrine falcons (*Falco peregrinus*; Hickey 1942) not only suggests that subgroups within species are common, but also reveals how they are perpetuated.

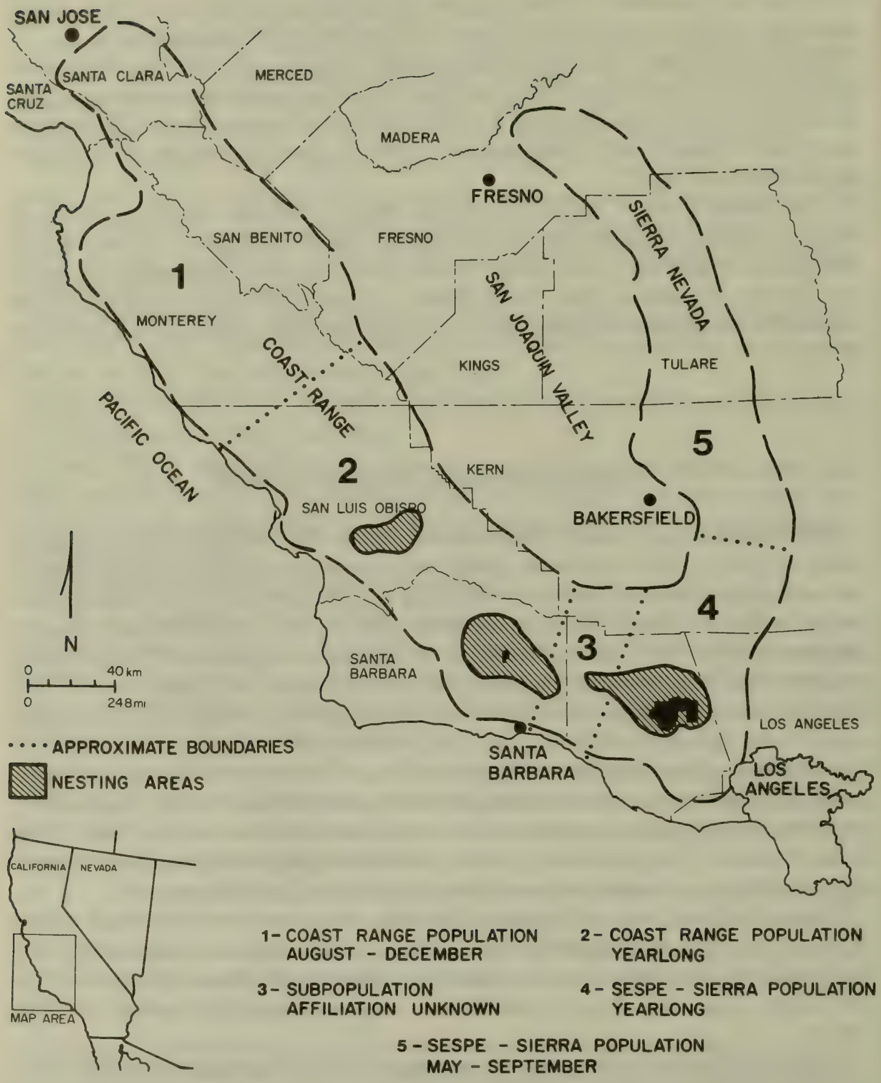

Fig. 4. Seasonal and geographical distribution of California condor subpopulations in relation to remaining nesting areas.

Changes in Distribution, 1966-76

No changes in either the overall range or areas used seasonally occurred during this 11-year period, but there were changes in the magnitude of use of certain areas. For example, condor numbers were high at Mt. Pinos each August from 1966 through 1969. In subsequent years, condor use has been "on schedule" seasonally, but total numbers have been much lower. August numbers in the Glennville area of Kern County were especially high in 1970-74, but some condors are usually in this area at that time every year. A few condors are usually in southern Tulare County in September; however, the 10-14 condors in that area during 1 week in September 1971 was an unusually large group for so late in the year.

Each of the changes noted appears related to differences in local food supply during particular years. Thus, individual condors are not so dependent on specific sites that they cannot respond to certain environmental changes. However, condors seldom seem to wander erratically, and they seldom appear at times or places where one would not expect to see them. Tradition, rather than food or any other factor, appears to be the major determinant of condor distribution.

Changes in Distribution, 1935-65

Condor range maps included in Koford (1953) and Miller et al. (1965) depict lesser distributional limits than I have described, although both reports include observations of condors north of their "normal" range in both Sierra Nevada and Coast Ranges. These birds were considered vagrants, but because neither study emphasized observations in the more outlying areas, it is likely that many visits by condors were unreported. Not enough data are available to make detailed comparisons, but it appears that there have been no significant changes in condor distribution spatially or seasonally since 1935, although there have been changes in magnitude of use in certain areas. Actual habitable acreage has been appreciably reduced as a result of increased urbanization and other changes in land use.

Although both Koford (1953) and Miller et al. (1965) apparently assumed one freely interchanging condor population, reports from their periods of study lend some support to my hypothesis that there are isolated subgroups of condors, and that this isolation is not a recent development. Condors passing between the Coast Ranges and the Sespe-Piru region would likely pass along the high ridges, past such locations as Nordhoff Peak, Reyes Peak, Whiteledge, Cuyama Peak, and Madulce Peak. Yet, even when large numbers of condors were known to be using both the Sisquoc Canyon area in the Coast Ranges and the Sespe-Piru area, and were believed to be traveling back and forth (Robinson 1940), observers at most of these locations reported condors only occasionally, and seldom more than two or three at a time (Koford 1953). At Madulce Peak in 1940, fire lookout B. Choice saw condors regularly, but they usually came from the Sisquoc Canyon area, circled near the fire tower, then returned in the direction from which they had come. Some condors could have circled up again high overhead and gone on to the east unnoticed, but if there was regular interchange in that vicinity, I think more evidence would be available.

Distribution, Before 1935

Koford (1953) discusses both the historic and prehistoric record of condor distribution in detail, citing Pleistocene and early Recent records of *Gymnogyps* vultures (either the current species or a very similar one) from California, Oregon, Nevada, New Mexico, Texas, Florida, and northern Mexico. He sets the post-1800 range as the Pacific Coast from the Columbia River between Oregon and Washington, south into northern Baja California.

Bones previously assigned to *Gymnogyps* at Shelter Cave, New Mexico (Howard and Miller 1933), have now been reassigned to *Breagyps* (Howard 1971). Locations where *Gymnogyps* skeletal material has been recovered are listed below.

1. Fossil beds
   Florida
      Reddick, Marion County (Brodkorb 1964).
      Seminole Field, Pinellas County (Wetmore 1931b).
      Hog Creek, Sarasota County (Wetmore 1931b).
      Itchtucknee River, Columbia County (McCoy 1963).
2. Tar pits
   California
      La Brea, Los Angeles County (L. Miller 1910; Howard and Miller 1939; Fisher 1944).
      Carpinteria, Santa Barbara County (L. Miller 1927).
      McKittrick, Kern County (Miller and DeMay 1942).
3. Cave deposits
   California
      Samwel Cave, Shasta County (L. Miller 1911).
      Potter Creek Cave, Shasta County (L. Miller 1911).
   Nevada
      Smith Creek Cave, White Pine County (Howard 1952).
      Gypsum Cave, Clark County (L. Miller 1931).
   Arizona
      Rampart Cave, Mohave County (L. Miller 1960).
      Stanton Cave, Coconino County (DeSaussure 1956; Parmalee 1969).
      Tooth Cave, Coconino County (DeSaussure 1956).
      Tse-an Kaetan Cave, Coconino County (DeSaussure 1956).
   New Mexico
      Rocky Arroyo Cave, Otero County (Wetmore 1931a, 1932).
      Howell's Ridge Cave, Grant County (Howard 1962).
      Conkling Cave, Dona Ana County (Howard and Miller 1933).
      Dark Canyon Cave, Eddy County (Howard 1971).
   Texas
      Friesenhahn Cave, Bexar County (Brodkorb 1964).
      Mule Ears Cave, Brewster County (Wetmore and Friedmann 1933).
   Mexico
      San Josecito Cave, Aramberri, Nuevo Leon (L. Miller 1943).

4. Indian mounds
   - Oregon
     - Brookings, Curry County (A. Miller 1942).
     - Five Mile Rapids, Sherman County (L. Miller 1957).
   - California
     - Emeryville, Alameda County (Howard 1929).
     - Santa Rosa Island, Santa Barbara County (Orr 1968).

Whether condors were year-long residents across the southern United States to Florida is not known. Part of the skeletal material from Howell's Ridge Cave (New Mexico), Rampart Cave (Arizona), and Mule Ears Cave (Texas) has been identified as belonging to nestling birds, indicating breeding at least east to Texas.

Koford (1953) did not include condor records north of the Columbia River, and tentatively concluded that all condors in the Pacific Northwest were vagrants from California, perhaps forced north in winter by food shortages. However, there are a number of apparently authentic records between the Columbia River and southern British Columbia (Douglas 1829; Macoun and Macoun 1909; Tolmie 1963). Also, although most records of condors on the lower Columbia River are from October to May, condors were present in the Pacific Northwest at other times of year. A specimen taken in the Columbia River area in 1825 was probably collected in late summer (Scouler 1905). Condors were observed in the Umpqua River area of Oregon from March through October (Finley 1908; Douglas 1914; Peale 1957), and in southern British Columbia in September and November (Macoun and Macoun 1909; Tolmie 1963). Information is biased by the small number of reports, and probably by seasonal travel patterns of observers, but it indicates year-long residency by condors in the Pacific Northwest. No condor nests were found in Oregon, Washington, or British Columbia, perhaps because few people visited the more rugged portions of this region before the species disappeared (Wilbur 1973).

Disappearance of condors from most of their range south and east of California apparently occurred with little influence by man. In those areas the condor was not a feature of Indian culture or legend as it was in California, and it was gone before man caused major environmental changes (unless primitive man was responsible for the disappearance of the large Pleistocene mammals, as suggested by Martin 1967). Increasing aridity in parts of the Southwest, and the loss of a significant vulture food supply following the disappearance of most large mammals (Mehringer 1967) may have been sufficient to make the area uninhabitable for condors.

In other areas, changes in distribution may be directly related to man's activities that caused entire subpopulations to disappear. For example, Monterey County, California, was once a major condor use area (Koford 1953), but the breeding population was apparently exterminated by shooting and egg collecting (to be discussed later). Although portions of the County still appear ideal for condor nesting, and condors are breeding a short distance to the southeast, nesting has not been reported since about 1902, and condors are seldom seen there now. A similar series of events occurred in the San Diego-Orange County area of California. If small, isolated subpopulations lived in the Pacific Northwest, Baja California, and elsewhere, the known impacts of habitat modification and direct mortality were sufficient to reduce those groups to low levels from which they could not recover.

Numbers

Population Size, 1966-76

It is difficult to estimate the total numbers of condors. Seasonal movements of the species involve some 4.5 million ha (10.8 million acres) of land (Rieger 1973), much of it rugged and isolated. Differentiating between individual birds and groups of birds is possible only on a very local and short-term basis (Wilbur 1975). Although more reliable observers than ever before are reporting condor sightings, there are still vast areas that are sparsely settled and receive only light and intermittent coverage. Considering these points, I think it is highly unlikely that all, or even most, condors could be seen in any given time period. Any population estimate based only on condors seen is probably low.

The highest positive count during 1966-76 was 34 condors on 24 October 1968 (Table 1). Several more condors can be safely added to this total. For instance, the October day totals include only two adult condors in Santa Barbara County, but an immature bird was known to be frequenting the area at that time. Similarly, only two of a known three-bird family group were observed in San Luis Obispo County. The third bird (immature) was known to be present both before and after 24 October, and was probably there on 24 October also. Four adult condors were still present in the Santa Barbara-San Luis Obispo area on 26 October, when two adults were seen far north of that region in Santa Clara County. It is unlikely that these birds came from outside the Coast Ranges, so they were probably not counted on 24 October.

Relating these 38 "sure" condors to the total population can only be done in a general way. During 1968 the current phase of condor research was well under way and key cooperators were reporting their sightings on a regular basis; therefore, probably few large groups of condors (more than five in a flock) could have gone unrecorded within the usual October range. In October, however, small numbers of condors are seen regularly in Tulare County, northern Kern County, and in the mountainous areas of western Ventura County; there are also confirmed and tentative sightings outside the "normal" range at this season. Considering the incomplete coverage of the possible range, it is highly likely that at least 10, and possibly as many as 20, condors were not reported. This would put the minimum population size in 1968 at approximately 50 birds and the maximum near 60.

Since 1968, both single and composite sightings have been fewer. Production during 1969-76 was about 13 young. Even if the long-term condor survival rate exceeded 95% annually, an extremely high level to maintain over a long period of time, mortality probably would have exceeded natality during that time. The current population almost certainly contains less than 50, and perhaps as few as 40 condors.

Changes in Condor Numbers, 1920-65

Koford (1953) estimated a population of 60 condors in 1920-50. Following essentially the same methods, but in a much shorter and less-detailed study, Miller et al. (1965) estimated 40 condors, a decline of about one-third between 1950 and 1965. The current estimate of 40 to 50 condors cannot be directly related to the results of those studies. Even trend comparisons are difficult because the observation staff is presently much larger than in earlier studies, local distribution within the overall condor range is somewhat different now, and some of the recent population information was derived from special "baiting surveys" that congregated birds near observers. After evaluating condor reports from various periods and estimating the effect that habitat changes may have on flock size and distribution, I conclude that the current population is smaller than in the early 1960's, and considerably smaller than in the 1940's and 1950's. If current condor population estimates are valid, both Koford (1953) and Miller et al. (1965) underestimated earlier condor populations.

If all condors belonged to one more-or-less freely interchanging, highly mobile population, it would be difficult to justify a population estimate much greater than the largest number of condors seen together at one time. For example, 20 condors seen in Tulare County 1 day could be the same 20 seen in Santa Barbara County 1 week later. Apparently both Koford (1953) and Miller et al. (1965) assumed complete and regular interchange, but as already discussed, this was probably not true.

If Koford's (1953) observations are considered on a subpopulations basis, his high single counts of more than 30 condors in the Coast Ranges and over 40 in the eastern segment of the range by themselves add up to a total population of more than 70 condors. Looking at the 1962 data (Miller et al. 1965), single counts of 8 condors in the Coast Ranges and 31 in eastern areas are recorded. Considering that some birds are scattered and unaccounted for at all seasons, a total well over 40 appears likely.

Comparing data included in Koford (1953) and Miller et al. (1965), it appears that the Sespe-Sierra subpopulation declined by about 10 birds between 1950 and 1965, and the Coast Range group by 15 or more. The number of dead condors found and the rumors of other losses in Kern County during the early 1960's (Miller et al. 1965) suggest an unusually significant period of condor mortality, and may account for most of the loss from the Sespe-Sierra population. Losses from the Coast Ranges appear to have been even more abrupt at about the same time, as 15-20 condors were roosting in San Benito County and foraging in adjacent areas until about 1963 (Miller et al. 1965; J. McIlroy, personal communication; F. Sibley, unpublished field notes). Movement of this number of condors in the Coast Ranges is well documented up to that time, and the abrupt cessation of reports suggests that some mortality factor affected the whole group at once.

Condor Numbers, Before 1920

Reliable condor population estimates are not available for the years before Koford's (1953) investigations, although figures ranging from 150 in the

Table 1. *Highest Positive Counts of Condors, 1966-76.*

Date	Number	Location	Observers
24 October 1968	27	Tejon Ranch, Kern County	R. Mallette, F. Sibley
	1	Snedden Ranch, Kern County	J. Borneman, G. Franklin
	2	Baldy, Ventura County	R. Fordice, T. Beck
	2	Salisbury Potrero, Santa Barbara County	W. Carrier, D. Connell
	2	Hi Mountain, San Luis Obispo County	R. Ferrari
Total	34		
8 August 1969	25	Mt. Pinos, Ventura County	J. Borneman, E. McMillan
	1	Cuyama Peak, Santa Barbara County	M. Jardequist
Total	26		
21 August 1970	22	Glennville, Kern County	E. Farnsworth
	5	Mt. Pinos, Ventura County	J. Leary, N. Snyder
Total	27		
7 October 1971	18	Tejon Ranch, Kern County	S. Wilbur
2 September 1972	24	Glennville	E. Farnsworth
	1	Cuyama Peak	G. Carpenter
Total	25		
25 October 1973	13	Tejon Ranch	J. Borneman, E. McMillan
	5	Tejon Ranch	W. Carrier, K. Axelson
	1	Hopper Canyon, Ventura County	M. Montagne, D. Warren
Total	19		

17 October 1974	12	Tejon Ranch	E. Harrison, L. Kiff, R. Quigley
	2	Tejon Ranch	J. Tarble, G. Nixon
	3	Santiago Canyon, Kern County	R. Fordice, R. Buss
	2	Agua Blanca, Ventura County	R. Long, J. Blake
Total	19		
7 July 1975	9	Springville, Tulare County	J. Miller
	2	Gold Hill, Ventura County	M. Giorgis
Total	11		
14 October 1976	2	West Big Pine, Santa Barbara County	M. Montagne, D. Smith
	10	Tejon Ranch	L. Kiff, R. Quigley
	4	Tejon Ranch	W. and D. Clark
	3	Agua Blanca, Ventura County	M. Silbernagle, J. Lindell
Total	19		

1920's (Phillips 1926) to 10 in 1932 (Atkinson 1972) have appeared in print. The much more extensive range, and the frequent use in the literature of such descriptive terms as "particularly abundant" (Gambel 1846) and "common" (Newberry 1857) suggest a population much larger than today's, but even in the 1800's it was unusual to see flocks containing more than 20 to 25 condors. The only reports that I found of really large flocks of condors, 150 to 300 in feeding groups, are somewhat suspect because they are included in an article full of misinformation and hearsay (Taylor 1859).

Whatever the early numbers, the consensus is that the condor population decreased appreciably after about 1840. Cooper (1890) recorded that condors had "rapidly grown scarce" between 1840 and 1890, and Henshaw (1876) noted that the population seemed to be "very much diminished during the last few years."

Past Causes for Condor Decline

As noted previously, prehistoric decline in condor numbers was probably related to changes in the carrying capacity of large areas of habitat, as the great herds of large mammals became extinct and condor food diminished. Later, the almost complete conversion to urbanization and agriculture of such areas as the Sacramento, San Joaquin, and Salinas Valleys reduced condor feeding area appreciably, and numerous roads and trails were made into mountain nesting and roosting areas. Until recently, none of these changes caused a shortage of food or lack of habitat. Factors suggested as causing, or contributing to, the decline of condors are evaluated below.

Indian Ceremonial Use

The California condor figures prominently in the religion and ritual of several California Indian tribes. The "Panes" festival, which involved sacrificing a young condor each year, was widespread in the State, and many tribes collected and killed their own bird (Bancroft 1882). Another ritual, known as the "Aswut Maknash" or eagle-killing ceremony, was practiced by the Temecula Indians of Orange County. Condors presumably were sometimes substituted for eagles (Parker 1965). Kroeber (1925) mentions condors kept as pets by Indians in Kern County, and notes that condor feathers were used in various ceremonies among tribes throughout coastal California from Humboldt County to Mexico. Russian settlers visiting the northern California coast in the early 1800's found entire capes made of condor feathers. Some of these were taken to Russia and are still in existence (Vaughan 1971).

Condors apparently were still relatively common during the height of these practices, and there is no evidence such activity caused any significant population decline. Because the condor was highly revered, it is doubtful there was killing other than that prescribed by ritual. However, considering the low reproductive rate of the condor, it seems possible that tribal activity kept the condor population at least stabilized and possibly slightly depressed in some areas.

Killing for Feathers

Several writers refer to the great demand for condor quills to be used as gold dust containers. Dawson (1923) felt it was an important decimating factor, and suggested that hundreds of condors must have been killed for that reason alone. Another writer (Siddon 1967) claimed that "a 'quill of gold' became a standard measuring unit in the gold fields."

In Baja California in the 1880's, Anthony (1893) saw Indian and Mexican miners carrying gold dust in condor quills, and saw condors (three?) that had apparently been killed for their feathers. In Los Angeles County, California, n 1841 "New Mexican" miners were seen carrying their gold dust in "turkey buzzard or vulture" quills (the term "vulture" usually referred to the California condor during that period; Bidwell 1966). These two reports constitute the only firsthand information on the subject I could find. I read 16 journals written during the California gold rush, and although several record observations of the California condor, none mentions the use of condor quills for gold storage. Invariably, miners are described as carrying their gold dust in buckskin pouches (Leeper 1894; Borthwick 1917; Johnston 1948). If the practice of using quills had been widespread, it would seem that references to it would have survived from that era.

Douglas' (1914) reference to condor quills being used for pipe stems was quoted in several works, but he was apparently misinformed. The same source told him of condors laying black eggs, nesting in trees, and laying two eggs per clutch. California condors apparently have not suffered from the efects of millinery trade that the Andean condor reportedly did (Chapman 1917).

Capturing for Sport

In one of the earliest general articles on condors, Taylor (1859) tells of hearing about condors involved in "the same custom of capture and sport . . practiced in Peru and Chile." Presumably men hid in pits and caught condors by the legs, then held contests with them against bears, dogs, and eagles. However, Taylor (1859) ". . . never had the opportunity of witnessing any of these fights." Harris (1941) made an extensive review of the literature of the period, and failed to authenticate such contests. My review of Gold Rush literature revealed numerous references to bear and bull fights, but none involving condors. If condor fights occurred, the total impact on the condor population was undoubtedly negligible.

There are reports of condors being run down on foot or horseback, or assoed, but most apparently involved sick or injured birds (Koford 1953). The practice of "penning" — catching condors in an enclosure big enough for them to land in, but not offering enough runway to take off again — is also mentioned as a condor mortality factor, but mostly as hearsay or in reports questionable on other grounds. For example, Shields (1895) derived information on "penning" from a man who also told him about condors killing ambs. Several older popular articles mention condors killing their prey, but there is no firsthand evidence that this occurs.

Wanton Shooting

Mortality resulting from malicious or ignorant shooters is one of the factors most often cited as a major cause of condor decline. Cooper (1890) reported many being shot, and Dawson (1923) considered the cause of condor mortality "first and foremost, gunfire." In the 1940's, Koford (1953) thought it probable that one condor per year was being shot. The case against shooting is in part inferential, based on condor vulnerability and shooter opportunity and attitude (Miller et al. 1965), but losses to gunfire are better documented than most other mortality factors. I have records (Appendix II) of 41 condors shot more or less without reason between 1806 and 1976. Because condor shooting has been illegal for many years, it is probable that most shooting incidents are unreported or unobserved. Shooting probably has caused a significant and continuous drain on the condor population since the early 1800's, with the magnitude of this loss increasing following the advent of the high-powered rifle in the 1890's (Chambers 1936). One confirmed shooting loss has occurred since 1960. Credit for the decline in shooting losses goes to improved legal protection and greatly increased public education.

Scientific and Hobby Collecting

Collecting of condors and their eggs has been suggested by several authors as one of the chief causes of condor decline (Dawson 1923; Fry 1926; Scott 1936b). Koford (1953) estimated that about 200 condors and condor eggs had been taken as specimens, and concluded that "undoubtedly collecting activity has contributed significantly to the decline of the condor in some areas."

Analyzing museum and written records, I found evidence of 177 condors killed and 71 eggs taken for additions to collections. Also, 24 live birds were taken for exhibit or as pets (Appendix II). At least 111 birds and 49 eggs were taken between 1881 and 1910 alone, and in a single 2-year period (1897 and 1898) at least 20 condors and 7 eggs were secured.

The disappearance of condors from various parts of their range coincided with peaks of collecting activity in those same areas. Koford (1953) estimated that condors had become very rare in Oregon and Washington by 1840, in California from Monterey County north by 1890-1900, and in coastal Santa Barbara County and in San Diego County by 1910. He thought condors in eastern Santa Barbara County and Ventura County were holding their own through the mid-1940's. The main periods of collecting activity were: Oregon and Washington 1805-35, Monterey and San Diego areas 1880-1900, Santa Barbara coast 1891-1910, and Ventura County 1901-24.

If the condor population is viewed as a series of smaller subgroups associated with known or suspected subgroup areas, then a correlation can be drawn between condor disappearance and collecting activity. Because condors have such low replacement potential, isolated groups could be quickly reduced to a level from which they could not recover. Because of traditional ties to their own subpopulations, condors would re-pioneer historic range very slowly or not at all.

Canada geese (*Branta canadensis*) provide an example of how this loss of subpopulations and abandonment of suitable habitat might have occurred. Habitat from which the resident population has been removed (for instance, by overshooting) may never be repopulated, even though Canada geese pass by the area and "know" that suitable habitat exists there. Hochbaum (1955) believed this occurs because all geese with local breeding experience are gone, and traditional ties to other localities (even less suitable ones) are too strong for geese to break. Hesitancy in re-pioneering areas formerly occupied by their species is shown by various other species of waterfowl (Sowls 1955) and by the common crow (Emlen 1940).

In the Pacific Northwest, at least eight condors were collected between 1805 and 1835. At least three more are known to have been shot during this period. If there was a local population of 1, 2, or 3 dozen individuals (Koford 1953), known mortality would have been enough to jeopardize it. If, as seems likely, more were shot than are recorded in the literature, combined collecting and other shooting could have exterminated the bulk of the population and reduced it below a viable level. A remnant could have survived in the area until the early 1900's.

Subpopulations were apparently larger in California, but collecting effort was also much greater. Collecting in each subpopulation area continued until condors and their eggs were no longer readily obtainable. At the end of the collecting era in the 1920's, substantial numbers of condors existed only in eastern Santa Barbara County and in Ventura County, and collecting was intensive in the latter area.

Poisoning

Many ornithologists in the late 19th century reported major mortality of condors from feeding on strychnine-poisoned meat (Baird et al. 1874; Henshaw 1876; Ridgway 1880; Cooper 1890; Bendire 1892). Later researchers concluded there was little basis for these earlier claims (Dawson 1923; Robinson 1940; Harris 1941; Koford 1953). In analysis, all the early reports appear to be hearsay and all apparently originated from information supplied by Taylor (1859), but his paper lacks definite information, and merely states that condors are "often killed by feeding on animals . . . poisoned by strychnine"; it is not clear whether he ever observed this. Taylor included a number of highly questionable stories in his account (e.g., condors attacking and killing calves, lambs, and rabbits), and there is no clear-cut line between reliable information and fantasy.

I was able to find only three firsthand accounts of condors being affected by poisons. Fry (1926) in 1890 saw two condors that had died, apparently after feeding on a sheep carcass treated with an unspecified poison. In 1950 three condors were found near a strychnine-treated carcass; one died, two presumably recovered (Miller et al. 1965). Another condor was found in similar circumstances in 1966 and judged to be strychnine-poisoned. Following treatment at the Los Angeles Zoo, this bird was released back to the wild (Borneman 1966).

Although some condors have fallen victims to poisoning, there seems to be no basis for reports of "great numbers" dying (Henshaw 1876). It is doubtful that poison losses figured significantly in the major condor decline of the late 19th century, but occasional losses since then have probably combined with mortality from other causes to keep the population level depressed.

Because the condor population's delicate balance could be upset by virtually any change in either birth or death rate, everything that retards productivity or increases mortality must share responsibility for any reduction in condor numbers. However, the combination of wanton shooting and purposeful collecting occurred at the proper time and in the magnitude necessary to have caused a major reduction in population size. Had these two factors continued in full effect for another decade past 1925, even the remnant populations of Santa Barbara and Ventura Counties might have been reduced below viable levels.

Recent Causes of Condor Decline

Apparently no single factor has caused a significant loss of condors since about 1960. Of the 16 known losses, 3 were victims of accidents and 2 were shot. Causes of the other losses are unknown. Cumulative losses for all reasons have apparently been greater than productivity during the past 15 years, thus a reduction in mortality is mandatory if the condor's status is to be improved.

Production

Production, 1966-76

Estimates of condor production are based on actual observations of known nest sites, observation of condor activity in known and potential nest areas, and on numbers of immature-plumaged birds observed during population counts. From 1966 to 1969 most nest sites were visited individually and the contents checked; since 1969, observations of nesting areas have been substituted for actual nest checks. Estimates of production by year follow. The first number after the year is the estimated total production and the second is the number of successful nestings known for certain (i.e., active nest found or recently hatched young seen): 1966-3/1; 1967-4/3; 1968-2/1; 1969-2/1; 1970-2/1; 1971-2/2; 1972-2/2; 1973-1/0; 1974-1/1; 1975-2/2; and 1976-2/2.

In any year, nesting activity by individual pairs may go unnoticed, so estimates of total production may be conservative. However, it is unlikely that more than one nesting pair per season is missed. Condors are very traditional in their use of nesting areas, returning again and again to the same general localities and even to the same nesting caves. All sites (except one known to have been used only once since 1938) are in locations with a long history of condor use. The estimated numbers of successful nestings are therefore believed to be very close to the actual production.

The apparent decline in annual production shown in the above estimates is confirmed by sightings of immature birds in the population at large. In

October 1968, August 1969, and August 1970, composite records indicated possible counts of 10, 10, and 13 immature-plumaged condors in the total population, based on high individual counts and geographical distribution of individual immature sightings. The same criteria yielded "composite probable" counts of up to eight immatures in 1971 and 1972. In 1973 only six immatures could be accounted for; in 1974 only four; in 1975, five; and in 1976, six.

Decreased productivity is a result of less reproductive activity, rather than decreased nest success. In fact, the percentage of nest success may have been greater since about 1970. For example, of four certain nesting attempts in 1966, only one resulted in a fledged immature. In 1967, three out of six known attempts were successful. Since 1970 only one suspected nest attempt has been unsuccessful. However, nest checking has been less intensive recently, and some nests that failed early in the season may have gone unnoticed.

Comparisons with Production Before 1966

In 4 years of study (1939-41, 1946), Koford knew of 13 condor nesting attempts, 9 of which were successful (Sibley 1969). This average of 2.25 young per year is superficially similar to the 1966-76 average. However, Koford did not conduct an extensive nest search — in fact did not visit all known nesting areas — so he undoubtedly did not find all nesting birds. On 13 April 1946 he saw 12 immature condors simultaneously, all of which had to be younger than 5 years of age. The probability of having all immature birds together in one place at one time is extremely low, and Koford himself estimated that there were 15-20 immatures in the population. Therefore, four to five young per year is probably realistic for that period, which requires that the reproductively active number of pairs in the population, assuming biennial nesting and some unsuccessful pairs, numbered 12 or more. Thus, some 40% of the population was engaged in reproductive effort.

There is good reason to believe that Koford's estimate of 60 birds in 1940-50 was low, and his failure to recognize distinct subpopulations of condors probably resulted in an underestimate of the number of young birds in the total population. Actual figures for number and productivity should be increased but, from the data available, it appears that 40% is a probable figure for the reproductive segment of the population then.

Miller et al. (1965) did no nest searching during 1963-64, and their effort to collect and analyze reports of condors was less exhaustive than other studies. Their records of at least 10 immature plumaged birds show a minimum average productivity of 2.5 young, and indicate that at least seven or eight pairs were reproductively active (again assuming biennial nesting and some nest failure). Beyond that, no valid comparisons can be made.

Among the current population of approximately 45 condors, 85% are adult-plumaged birds. If reproductive activity began with attainment of adult plumage, if sex ratios were equal within the population, and if there was free mixing of all condors throughout their range, then a maximum of 19 pairs could be formed. Assuming that each pair nested biennially, 9 or 10 nesting attempts would be possible each year.

Actually, it seems likely that first breeding is deferred for some years after adult plumage is attained. A captive California condor was 12 years old before laying its first egg (Dixon 1924). First breeding in captive Andean condors usually occurs at 8 to 10 years (Lint 1959; Anon. 1976). Golden eagles (*Aquila chrysaetos*) attain adult plumage at about 3½ years, but do not breed until their 5th year (Jollie 1947; Spofford 1964).

The sex ratio is probably uneven in the condor population. My examination of museum records showed that 60% of the specimens taken were males. Sexes look identical, and most condors were collected away from nests, so there should not have been appreciable differential mortality from shooting. It has been hypothesized that males survive better than females in species that are not sexually dimorphic (Cody 1971).

Finally, the occurrence of distinct subpopulations limits the mixing of condors from different regions, reducing the likelihood that all potential breeding birds will find mates.

Minimum breeding age, sex ratio, and spatial distribution probably all affect the reproductive potential of the condor population. Unfortunately, we do not yet know the magnitude of each effect. If there are 60% males in both subpopulations, and if normal age of first breeding is 8 to 10 years, then there is the potential for 12 breeding pairs, or 6 breeding attempts per year.

Actually, only a couple of pairs attempt to breed each year, much lower than would be expected in any situation except an extremely disparate sex ratio. Determining the cause of reduced reproduction and correcting the situation is currently the key to condor survival.

Control of reproduction in birds and mammals still is not completely understood, but it is clear that success involves a precise blending of a number of factors. Photostimulation by increasing day length may be enough to induce a high level of sexual readiness in the male but not in the female. She requires interaction with the male before ovarian development is complete (Lehrman 1959; Immelmann 1971). Even when the internal physiology is wholly prepared, reproduction is greatly influenced by various stimuli and inhibitors. Stimuli such as adequate food or nest site availability act as releasing mechanisms that allow progression to the next stage of the reproductive cycle, and initiate actual nest building and egg laying (Lehrman 1959; Immelmann 1973). Inhibitors, such as sudden cold, fear, nest destruction, or chemicals, may block the reproductive process at any point (Marshall 1961; Cade et al. 1968). If inhibitors are too strong, or final external stimuli are lacking, reproduction will not occur (Marshall 1952, 1961; Immelmann 1971, 1973).

Food Supply

The relationship of food and welfare of the California condor has been discussed and studied for a number of years. Early researchers (Robinson 1940; Koford 1953) thought that food supply was already becoming a limiting factor in the 1930's and early 1940's. Koford (1953) described changes in food supply as the second most important factor affecting distribution and

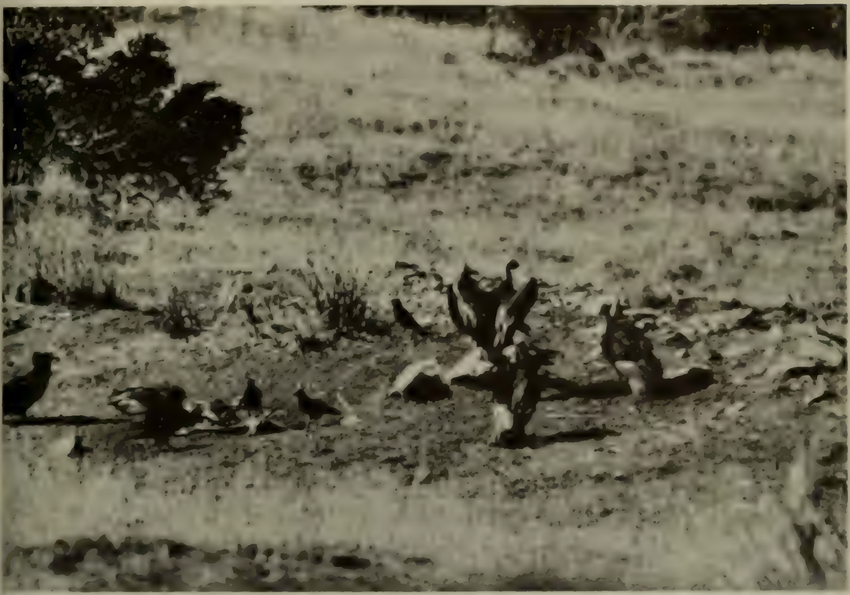

Fig. 5. California condors and ravens gathered at mule deer carcass. (Photo by Sanford Wilbur)

numbers of condors in the past century. He thought direct persecution by man was the most important. A study made in the early 1960's (Miller et al. 1965), however, concluded that food supply for condors was adequate at all times of year, and had not been a limiting factor "since the 1920's." These later findings were based on what researchers considered adequate reproduction and an estimated overabundance of food within the condor foraging range. These authors apparently assumed condors were free to forage into all parts of their total range at all times of year, an assumption that is invalid. Miller et al. (1965) also failed to adequately differentiate between the total amount of food within the condors' range (i.e., all animals that die) and the amount of food actually available to condors (Brown and Watson 1964; Immelmann 1971).

Foods Eaten

California condors feed only on the carcasses of dead animals, primarily mammals (Fig. 5). Many species are eaten but, as Koford (1953) noted, domestic cattle constitute the most important food source by far. Cattle are even more important today than during Koford's research period, because domestic sheep have declined drastically in California (California Crop and Livestock Reporting Service 1970), and more are grazing outside normal condor range (Burcham 1957). Mule deer (*Odocoileus hemionus*), while possibly a "preferred" food (Koford 1953), tend to drift toward canyon bottoms to die (Blong 1954; Taber and Dasmann 1958), where steep terrain and brush interfere with condor foraging. Carcasses under brush are hard to see, and condors apparently cannot locate food by smell (Beebe 1909; Stager 1964). Thus, deer have probably never been a major food item for condors, and expansion of the deer population in some areas (Miller et al. 1965) and apparent declines in other areas have not altered condor food supplies overall. Ground squirrels (*Citellus beechyi*) killed by animal control programs have been locally important food sources in the past (Koford 1953), but are now seldom available in numbers. All things considered, an evaluation of condor food supply must consider cattle availability first, followed by other sources to the extent of their quantity, periodicity, and dependability within the condor range.

Amount of Food Required

A 9-kg (20-pound) California condor has a standard metabolism of about 350 kcal/day, as computed from the formula in King and Farner (1961). Converting to the metabolic rate of a free-flying bird is still speculative, because free-flying metabolism of other large birds has been experimentally estimated at from 2 to 4 times standard metabolism (Kahl 1964; Houston 1971; Jarvis et al. 1974). Depending on which is more correct, a California condor may have a free-flying metabolism of 650 to 1,300 kcal/day. Food eaten by condors has an energy value of about 1.25 kcal/g (Houston 1971), so the daily food requirement of the condor is from 525 g (1.1 pounds) to 1,040 g (2.2 pounds).

A captive California condor ate approximately 1 kg (2 pounds) of meat per day (Todd and Gale 1970), and maintained an average body weight of 9.98 kg (22 pounds; Todd 1974). Other large birds of prey eat daily amounts of food averaging 7 to 10% of their body weight (Craighead and Craighead 1956; Brown and Amadon 1968).

Condors cannot forage every day because of occasional periods of inclement weather, and I have seen them stay near roosting areas all day even in favorable weather. Probably the usual daily situation is that a condor either gets much more or much less than the average daily food requirement. African griffon vultures (*Gyps africanus* and *G. ruppellii*) can hold up to one-fifth their body weight in their crop and can rapidly store fat after a large food intake. Maximum fat stores and expendable protein have been found sufficient to maintain them at least 15 days without feeding (Houston 1971). Captive turkey vultures (*Cathartes aura*) deprived of food up to 11 days maintained normal body temperature and remained healthy (Hatch 1970). The California condor can undoubtedly respond in similar fashion.

In addition to supplying their own energy needs, successfully nesting condors must provide food for one nestling. The daily food requirement of a growing raptor is equal to that of an adult (Brown and Amadon 1968), so a breeding pair of condors require about 3 kg (6 pounds) of food per day. Condors usually feed their young every day, although nestlings have been known to survive without food for up to 45 h (Koford 1953). How the chick's ability to go without food compares to the adult is unknown.

Required Location of Food

Condors are able to travel long distances in search of food. Their normal soaring speed is estimated at 50 km/h (30 miles per hour; Koford 1953), and in midsummer there may be as many as 6 h per day in which atmospheric conditions are suitable for soaring flight. (In winter there are seldom more than 4 soaring hours.) Theoretically, condors might travel 125-175 km (75-100 miles) on a summer day.

Actually, effective foraging time and range are much less than maximum. Foraging involves much circling and searching, as well as direct flight. When a carcass is located, condors often do not immediately descend to it. If a coyote (*Canis latrans*) or golden eagle is feeding on the carcass, they may prevent condors from feeding for some time. On one occasion, I observed nine California condors waiting at a deer carcass for 45 min while an eagle fed.

Tradition is also important in determining food availability. As described earlier, condors are predictable in their seasonal distribution. Although they adapt to minor changes in food location, it is unlikely that under most conditions they would move far outside their normal seasonal range to search for food. For raptorial birds generally, attachment to a given traditional area has little to do with the resources available to that area (Craighead and Craighead 1956). Therefore, although food is available in Tulare County in December, it will not be available to condors who are traditionally elsewhere at that time. Neither would I expect condors from Ventura County to forage in San Luis Obispo County at any time of year, because the historic record suggests the lack of a traditional tie between those areas. As will be discussed later, traditions can be broken, but only with great difficulty, and with possible serious effects on other aspects of species' survival.

Distances between known nesting and roosting areas and regularly used feeding areas are generally less than 50 km (30 miles; Koford 1953). Although some food may be obtained at greater distances, breeding condors probably obtain almost their entire annual livelihood within 50 km of the nest. Nonbreeding birds are undoubtedly more flexible, but probably also obtain most of their food within 50 km of whatever roost they are occupying.

Current Food Situation

Coast Range Condors

There have been land-use changes that have made certain areas (e.g., the major valleys and areas close to cities) unsuitable for condors in the Coast Ranges. However, reports from county farm advisors and my own observations show that there are still vast acreages of rangeland well stocked with livestock and deer (Fig. 6). Little decrease in the condor food supply is anticipated in the near future. The maximum of 10 condors now using this area should have little trouble finding adequate food, although they may have to move considerable distances at times.

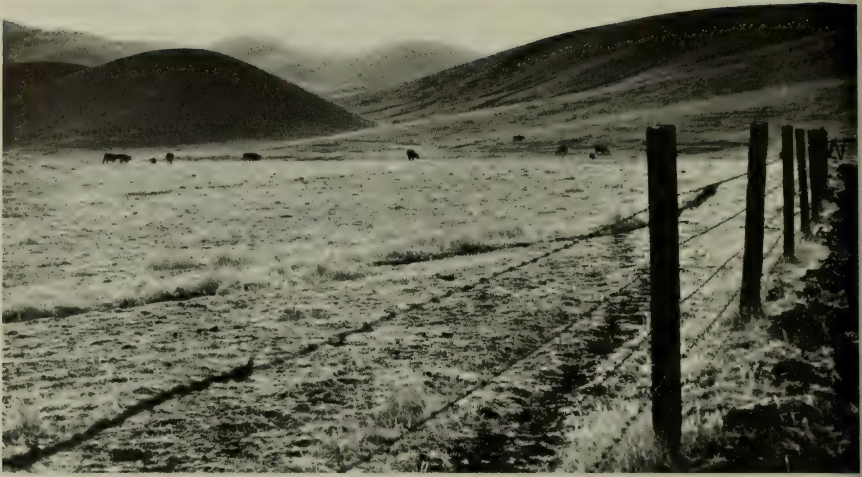

Fig. 6. Typical Coast Range feeding habitat for California condors. (Photo by Sanford Wilbur)

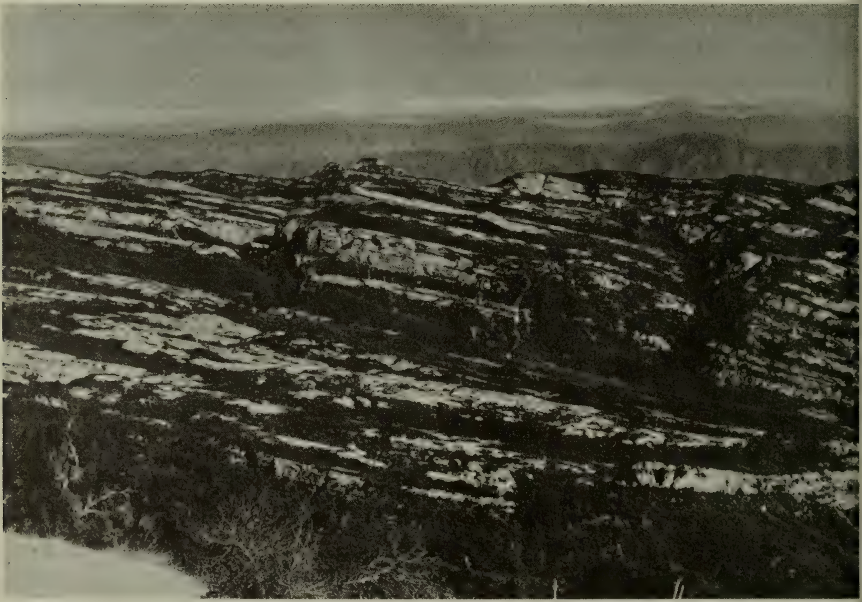

Fig. 7. Hopper Canyon, Sespe Condor Sanctuary, an important condor nesting and roosting area. (Photo by Sanford Wilbur)

A food problem may exist for breeding condors in the Coast Ranges. Although known nesting sites in San Luis Obispo County appear well supplied with local food, the area can support only a few pairs of condors because of few nesting sites. In Santa Barbara County there is considerable nesting habitat that has been used in past years, but the local food situation had apparently deteriorated by 1940 (Koford 1953), and the downward trend has continued. Deer numbers may be increasing near nesting areas in response to improved habitat, including the results of fire and brush manipulation, but livestock numbers have decreased on both east and west sides of the area (L. V. Maxwell, farm advisor, personal communication). I doubt that this area has enough food to support more than a few pairs of breeding condors.

Nesting areas exist in Monterey County that still appear suitable for condors and might be repopulated in the future. The food supply in that region seems adequate for several breeding pairs.

Summer is the critical food season in the Coast Ranges. Almost all livestock mortality occurs in late fall, winter, and spring. Occasional deer die-offs may provide abundant food in local areas at other times of year, but such occurrences are unpredictable and cannot be considered a regular part of the condors' food supply. The summer food slump in the Coast Range is sufficiently extreme that it may be a limiting factor in the expansion of the condor population.

Sespe-Sierra Breeding Population

The region in and around the present-day Sespe Condor Sanctuary, designated the Sespe-Piru area, has been an important condor nesting and wintering area since at least 1880 (Koford 1953), and probably for many centuries before that (Fig. 7). It is a logical choice because it is rugged and isolated, and has numerous sandstone cliffs with caves for nesting, coniferous trees for roosting, and shallow pools for drinking and bathing. Although there are other suitable nesting areas in other parts of the condors' range, the Sespe-Piru region is certainly the most expansive in terms of acreage and number of individual nest sites. Historically, it was a logical choice for a breeding area because of a food supply that was nearby and abundant throughout the year. Pronghorn antelope (*Antilocapra americana*), tule elk (*Cervus nannodes*), and mule deer were common within foraging distance (Dasmann 1958), and the local seacoast undoubtedly provided food in the form of dead whales, sea lions, and other marine life (Koford 1953). As native mammals became less abundant, domestic cattle and sheep increased and provided an alternate, and possibly more plentiful and reliable, food source. Potential food supply was well distributed in Ventura and Los Angeles Counties south of the Sespe-Piru area, and to the east in Kern County, making the nesting area the hub of a large foraging area.

Koford (1953) described various changes in livestock numbers and land use in the Sespe-Piru region that together caused considerable decrease in foraging land and potential food supply before 1940. For example, he documents a major decline in sheep numbers in Ventura and Kern Counties in the early 1900's and again in the 1930's. Although cattle numbers increased during that time, Koford (1953) concluded that the increase was not sufficient to make up for the loss of sheep as a source of condor food.

Since 1940 the local food situation has continued to deteriorate. Between 1960 and 1970, large acreages of condor foraging habitat in southern Ventura and northern Los Angeles Counties disappeared beneath new residential and industrial developments. The Agoura-Calabasas area tripled its human population in that 11-year period; the Thousand Oaks-Westlake district was 4 times larger in 1970 than in 1960; and the Simi Valley population increased 600% in that period (Security Pacific National Bank 1970). As a rough measure of loss of condor foraging habitat, I compared extent of urbanization shown on two sets of U.S. Geological Survey maps (7.5 minute quadrangles for Newbury Park, Thousand Oaks, Moorpark, Simi, and Santa Susana), the first completed in 1950 and 1951 and the second copies of the same maps photorevised in 1967 and 1969. In that 80,000-ha (200,000-acre) area, roughly 8,000 ha (20,000 acres) of condor feeding habitat have been completely urbanized in that time period. The actual loss is much higher because even where "rangeland" still exists, it has been divided into small parcels with considerable human activity and is seldom used by condors.

Outside the Simi-Thousand Oaks area, less drastic but similar events have occurred. Much of the remaining rangeland is held by land companies who plan future development. In a report prepared by the Ventura County Planning Department (1970), it was estimated that if current county and city policies are continued, in the next 50 years the current 92,000 ha (227,000 acres) of open "developable" land in Ventura County will shrink to 44,000 ha (109,000 acres). Little has happened in the ensuing 7 years to modify this prediction.

The general decline of sheep in California is reflected in Ventura County by a reduction in numbers of perhaps 25% between 1950 and 1969. In that same period, range cattle decreased from about 30,000 to 20,000 (E. L. Bramhall, farm advisor, personal communication). Much of this decrease was in the Moorpark-Thousand Oaks-Simi region, the foraging area closest to the main nesting areas of the Sespe-Piru region. In western Kern County, the number of cattle increased somewhat in recent years, but improved handling has reduced mortality so it is doubtful that the condor food situation has improved there (H. E. Thurber, personal communication). The future trend on the Tejon Ranch properties is expected to be toward fewer livestock, and more farming and other habitat-modifying uses.

According to various local ranchers and farm advisors, most livestock losses in this area occur between September and February, with only scattered mortality through the spring and summer months. Most deer mortality occurs during the same period (Blong 1954), although there may be major die-offs at any time of year. Overall, it appears that condor food may still be adequate in the area in fall and winter, but it seems highly unlikely there is now enough food in spring and summer to sustain a large number of condors.

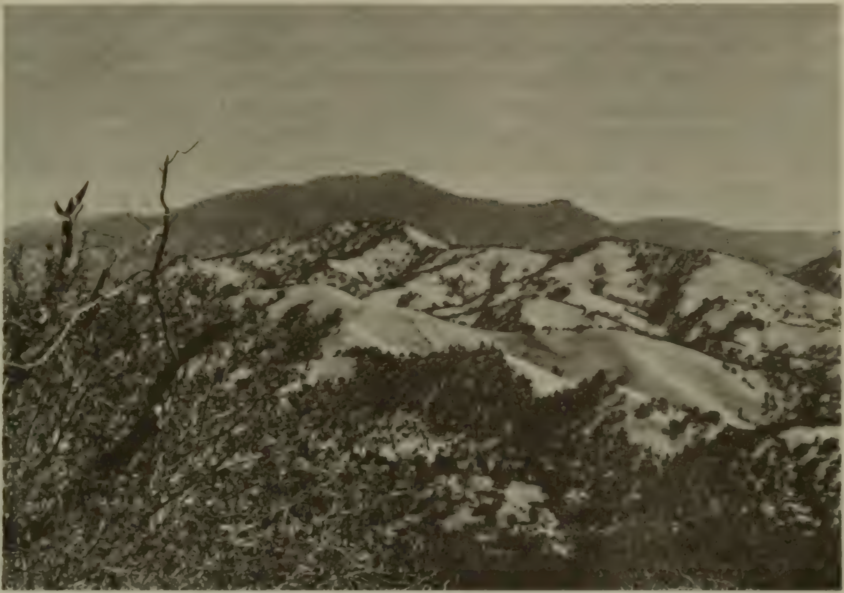

Fig. 8. Feeding habitat used by Sespe-Sierra nonbreeding condors.

Sespe-Sierra Nonbreeding Condors

The foraging area of the Sespe-Sierra nonbreeding group of condors has been shrinking in recent years (Fig. 8). Citrus groves in Fresno and Tulare Counties have been extended several miles eastward into former rangeland. There has been a similar expansion of other farm crops in the area south and east of Bakersfield in Kern County. A trend toward dividing large ranch holdings into family "rancheros" of 8-16 ha (20-40 acres) is evident in Fresno County and southern Kern County. Although these small ranches remain as open space, they are of little value to condors because of related disturbances and a general lack of food, resulting from fewer livestock and more sanitary methods for the disposal of carcasses.

As in other portions of the condors' range, summer is the season of lowest food supply. There are less livestock on the range than in fall and winter, and there is no major livestock mortality during summer. From April through early August, it appears the condors must forage widely for food.

Possible Effects of Food Shortage

Although condor food appears in short supply, particularly in summer, there is no evidence that condors are starving, or are likely to do so in the near future. If, as seems reasonable, a condor requires 1 kg (2.2 pounds) of food per day, a population of 50 condors requires 18,000 kg (39,600 pounds) of food per year. Assuming condors obtain only 23 kg (50 pounds) of food from the average ungulate carcass (and many carcasses provide much more), only 720 carcasses will be required per year (60 per month). There are certainly many more than that available, although harder to find at some seasons and in some areas.

Besides causing actual starvation, inadequate food can cause birds not to breed at all, to defer breeding to an older age, to nest intermittently, or to nest unsuccessfully.

Failure to Breed

Immelmann (1971) stated that much circumstantial and some experimental evidence exists for the importance of nutrition in spermatogenesis and oogenesis in birds. Apparently, the reproductive function is a physiological luxury in time of food lack, and is then curtailed in favor of specific survival needs (Assenmacher 1973). Food, visually or physiologically, acts as a releaser for the breeding cycle. For example, wood storks (*Mycteria americana*) fail to breed if fish are not available at certain optimum levels (Kahl 1964). The reproductive cycle of long-tailed jaegers (*Stercorarius longicaudus*) may stop if food supply fails (Drury 1960), and some African birds of prey apparently fail to breed if they cannot find sufficient food at the start of the breeding season (Brown 1953). In some instances, if the normal food intake of the domestic chicken is reduced 25%, gonad activity almost ceases (Marshall 1961).

A limited food supply and the effects of social dominance may result in nonbreeding by some members of a bird population. Most populations have a hierarchy or "peck order" that ensures dominant members will fare better than those lower in the order (Davis 1952; Wynne-Edwards 1962). If food is scarce, only the most aggressive birds will eat, which has been shown in populations of griffon vultures (Houston 1971), and Marabou storks (*Leptoptilos crumeniferus*; Kahl 1966), and has been suggested for various seabirds (Ashmole 1971).

If an inordinate amount of time is required to find food, there may not be enough time, energy, or inclination left for reproductive activity. For example, royal penguins (*Eudyptes chrysolophus*) have only one nesting area and a limited nesting season. Although the ocean as a whole has adequate food, "there are obvious limits to foodfinding time and foraging distances beyond which breeding success is impossible" (Carrick 1972).

Finally, lack of food near nests may indirectly arrest breeding. Although traditional ties to breeding areas are very strong, continued lack of food sometimes forces populations to desert favored areas, permanently or temporarily (Lack 1937; Marshall 1951; Brown 1953). Adequate food may be the releasing stimulus of breeding activity, but the nest site may function similarly. If lack of food in one area forces birds to move into another area without adequate nest sites, reproduction might not take place (Lehrman 1959; Marshall 1961; Immelmann 1973).

It appears that food in the vicinity of the Sespe-Piru nesting areas may be inadequate to stimulate the reproductive function in some condors. Observations of condors feeding indicate there is a well-defined "peck order," with certain individuals and pairs dominating carcasses to the almost complete exclusion of others. General scarcity of food requires that condors spend long periods foraging, so there may be insufficient time for both foraging and reproduction.

I also suspect that food scarcity is the cause of an overall decrease in condor use of the Sespe-Piru nesting area during all seasons, and that this is inhibiting productivity. In the 1940's the area supported winter populations of over 30 condors, and 8-10 condors were seen regularly in mid-summer (Koford 1953). During the early 1960's, high winter counts included about 20 condors (Miller et al. 1965); summer observations of up to 4 birds together were common (U.S. Forest Service patrolman reports). Since 1965, highest winter counts have been of 11-13 condors, and summer records seldom include more than 2 birds together. Some of the decline in use is due to decrease in size of the total condor population, but the declines are not comparable in size or timing. It appears that most condors have shifted their winter quarters from the Sespe-Piru area to the mountains of southern Kern County, where a substantial food supply still exists in fall and winter. The traditional move into the nesting area at the start of the breeding season no longer occurs. There are few sites in Kern County that are comparable to known nesting habitat, even though feeding and roosting habitat is excellent much of the year. Stimulation to breed may occur only in the presence of typical condor nesting habitat.

Deferral of Breeding and Intermittent Breeding

Deferred breeding beyond normal minimum reproductive age has been shown to be a function of both nutrition and competition. As examples, in seabirds (Ashmole 1971), griffon vultures (Houston 1971), Canada geese and trumpeter swans (*Cygnus buccinator*; Palmer 1972), and pied flycatchers (*Ficedula hypoleuca*; von Haartman 1972), younger, inexperienced birds cannot successfully compete with established pairs for limited food supplies. In mammals such as the black bear (*Ursus americanus*) and *Odocoileus* deer, there is a direct relationship between minimum breeding age and nutrition; animals from food-shortage areas breed initially at an older age (Klein 1970; Jonkel and Cowan 1971; Robinette et al. 1973).

Breeding intervals greater than the normal biological limits may result if food is inadequate (e.g., Jonkel and Cowan [1971] relate nutritional levels to frequency of litters in the black bear). Condor food supply appears low enough that there may be deferred or irregular breeding, but minimum breeding ages and the reproductive performance of individual pairs are unknown. There is some evidence that the long period of juvenile dependency that often keeps condors from nesting every year (Koford 1953) is environmentally, rather than physiologically, controlled. That the species can lay eggs in successive years has been shown with captive condors, and is suggested by several instances when an egg was found in a nest from which one had been removed the previous year (Koford 1953). Dependence of the immature into the year following hatching is usually not due to its physical condition (it can fly to and from feeding areas with its parents by the end of the hatching year), but is the result of social pressure. Young birds cannot compete successfully at a carcass with either adults or older young, so adults must eat for their offspring as well as for themselves. Apparently variations in food supply do not change actual growth and development rates of young birds (Houston 1971; Ricklefs 1973), but if food is plentiful enough to allow young to feed unmolested at an earlier age, adults might begin a new reproductive cycle the year following successful nesting. That this may occur is suggested by the fledging of four condors from one nest cliff in four consecutive years, 1966-69 (F.C. Sibley, unpublished reports). This site is isolated from other nesting areas, and few condors use nearby feeding areas. Although there is no certainty that the same pair was involved each year, the site tenacity of individuals is generally well known among birds (Broley 1947; Austin 1949; Herbert and Herbert 1965; Coulson 1966; Brown 1972) and more than two adults are seldom seen anywhere near this particular nest site. The only obvious difference between this and other nest areas is an abundant nearby food supply and very little competition from other condors.

Unsuccessful Breeding Efforts

Inadequate food is known to reduce fertility in birds (King 1973) and mammals (Klein 1970; Robinette et al. 1973). Better conditioning promoted by good nutrition reduces mortality of young mammals (Klein 1970; Robinette et al. 1973) and probably of birds. Additionally, loss of eggs through chilling during long food-searching absences by the parents, or loss of nestlings to starvation, are possible food-related occurrences.

Currently, there is no evidence of food scarcity or any other factor reducing the success of nesting attempts. The few nests started in recent years usually have fledged young.

Food shortages may affect condors in less direct ways than those described above. As foraging habitat diminishes, condors are forced to congregate in fewer areas and in larger groups. This increases their vulnerability to shooting and other man-related mortality. Also, food shortage may cause mortality or reduced productivity under stress by mobilizing pesticides stored in the body. For instance, DDT may accumulate in body fat with no immediate toxic effects, and be gradually eliminated by normal bodily processes. However, if the system of the bird is stressed as during decreased food intake, stored fat is utilized and DDT is released in harmful — sometimes lethal — doses (Stickel 1969; Van Velzen et al. 1972). Pesticide relationships will be discussed later.

Disturbance

The reaction of condors to human activity varies with the duration and intensity of disturbance, whether it is noise or physical presence, and may involve flying, roosting, feeding, or nesting behavior.

Flying Condors

Flying condors show little fear of man and will often approach closely. They may even glide to a person walking along an exposed ridge, or sitting in an open area, and circle over him. Apparently the more conspicuous a person is and the more commotion he makes, the more likely a condor is to approach. Whistling and arm-waving may prolong the time the bird remains overhead (Sibley 1969).

Condors in flight do not avoid areas of human occupancy. I have seen them regularly over the oil fields near the Sespe Condor Sanctuary, and a regularly used condor flight lane follows Interstate Highway 5 through the Tehachapi Mountains. Condors are occasionally reported flying over Bakersfield, San Jose, and other cities and towns. Although there may be a limit to the amount of ground disturbance a flying condor will tolerate, most traditional flight lanes will probably be traveled as long as related nesting, roosting, and feeding areas are usable.

Roosting Birds

Condors usually return to traditional roosting areas each afternoon. At many of these roost sites, the same trees and rock ledges have been used for at least 35 years, while nearby perches that appear identical remain unoccupied.

Roosting condors are readily disturbed by either noise or movement, and disturbances late in the day may prevent roosting that night (Koford 1953). However, reaction to disturbance varies. On 31 May 1972, I walked to within 9 m (30 feet) of a year-old condor, took photographs, then entered a nearby bird blind. The young bird sat on the snag for another 30 min, departing then only because an adult condor forced it from its perch. In contrast, on 13 January 1970, movements of one person along a trail over 0.4 km (0.25 mile) from a roosting condor apparently caused it to change its perch several times and eventually leave the vicinity. Two condors roosting in a snag on 19 August 1971 showed no reaction to a sharp sonic boom, yet flew hastily from the tree when a fixed-wing aircraft passed within 300 m (1,000 feet) of them. A startling sonic boom on 7 October 1971 caused three adult condors to hurriedly leave their roost area.

Occasional major disturbances will not cause condors to abandon regularly used roosts, and they may adapt to general low-level disturbance. A summer roosting area in Tulare County is less than 1 km (0.6 mile) from radio towers, a fire lookout, and summer homes, yet is occupied by condors almost every night from May to September. However, noise levels are low and few people actually approach within 0.4 km (0.25 mile) of roost trees. Some levels of noise and activity will cause condors to permanently leave an area; two roosting areas were abandoned near the Sespe Condor Sanctuary. One area, on the west side of Hopper Ridge 1 km (0.6 mile) north of Hopper Mountain was regularly used by condors in 1939 and 1946. There was some disturbance in the area, including an occasional automobile being driven within 50-100 m (150-300 feet) of the site. Now there is a battery of oil wells

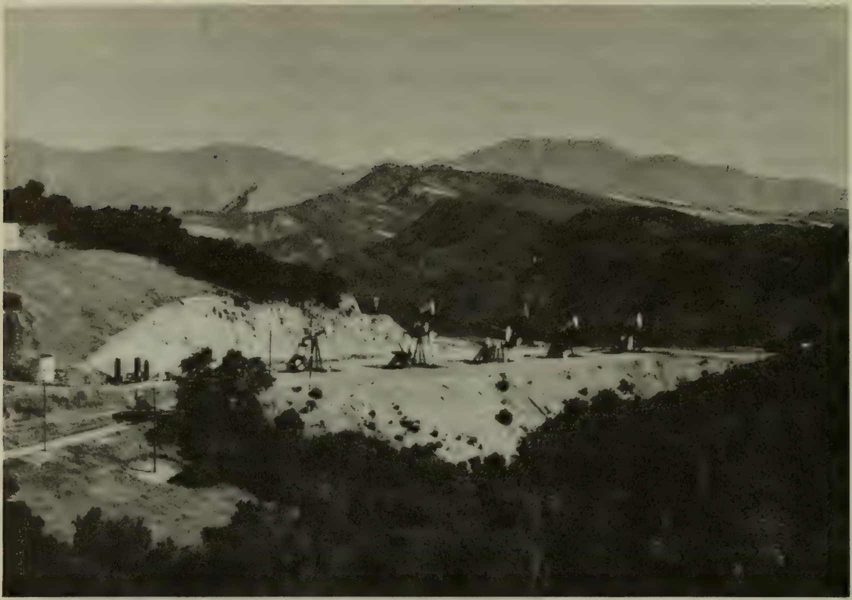

Fig. 9. Oil field development at the edge of the Sespe Condor Sanctuary. Condors formerly roosted along the ridge immediately behind the pumps. (Photo by Sanford Wilbur)

1 km (0.6 mile) away in line of sight of the roost trees, and there is almost constant, but usually low-level, noise and oil-related activity. Condors no longer roost on the west side of Hopper Ridge in that area, although they continue to roost within 2 km (1.2 miles) of the oil operation where roosts are shielded topographically from sight and most sound of the oil fields (Fig. 9).

A second roost site was located in cliffs of Pole Creek, about 2 km (1.2 miles) southwest of Hopper Mountain. Condors were seen there regularly in 1940 and 1941, and the regular presence of a very young condor one year suggests it may have been a nest site as well. There was a lightly-traveled farm road within 1.2 km (0.75 mile) of the roost, and some limited oil exploration had occurred about 1.5 km (1 mile) away. Now a major portion of the Sespe Oil Field occupies the area within 1.5 km (1 mile) of the roost, and there are producing oil wells within 1 km (0.6 mile). It has not been used by condors for many years.

No one was systematically documenting condor observations on Hopper Mountain during 1950-65, so it is not possible to show a positive cause-and-effect relationship between oil field development and abandonment of these roosts. However, lack of use at these sites, contrasted with continued condor occupation of traditional roosts just beyond the influence of the oil fields, suggests such a relationship.

Feeding Birds

Condors normally feed in relatively isolated areas and usually leave if approached within a few hundred meters (about 1,000 feet) by vehicles or people (Koford 1953). They seldom feed on animals killed on highways or in areas of regular disturbance. Koford (1953), however, recorded them feeding within 600 m (500 yards) of an occupied ranch house, and on several occasions I have observed them feeding within a few hundred meters (1,000 feet) of well-traveled roads.

Startling noises sometimes frighten condors from food; on 1 May 1969 a sonic boom caused four condors to fly up and the remaining two to run some distance from a carcass. On 2 May 1969 a sonic boom caused condors to fly from a carcass briefly, but a second boom elicited only a mild startle reaction (heads up, looking around; F. C. Sibley, unpublished field notes). One condor and six turkey vultures I observed at a carcass on 3 August 1972 showed no apparent reaction to a moderately loud sonic boom.

Condors have abandoned feeding sites once used regularly, but most such sites have a greatly diminished food supply as well as increased human disturbance. Probably the greater and more regular the disturbance, the less likely condors are to feed in the area.

Nesting Condors

Sibley (1969) plotted the location of condor nest sites in relation to roads, trails, and oil field activity. He found that, even though apparently suitable nest sites existed closer, no occupied nest sites were located nearer to various developments than the following:

1. *Lightly used dirt roads* — 1.3 km (0.8 mile) when the site was unshielded from sight and sound of the road, occasionally closer (0.8 km, 0.5 mile) when completely shielded.
2. *Regularly used dirt roads* — 2 km (1.2 miles) when unshielded, closest shielded about 1.2 km (0.7 mile).
3. *Paved road* — 3.5 km (2.2 miles).
4. *Oil wells* — 3.7 km (2.3 miles) when nest was in view of the well, 2 km (1.2 miles) when shielded from sight and most sound.

Both regularity and magnitude of disturbance are involved in discouraging condor nesting, as nests may be located nearer to lightly used roads than to regular travel routes or oil operations. Condors have nested very near intermittently used foot trails. It appears that the greater the disturbance, either in frequency or noise level, the less likely condors are to nest nearby. Since 1965 nests are known to have hatched successfully 0.8 km (0.5 mile) from an infrequently used administrative road, 1.3 km (0.8 mile) from a regularly used dirt road, 3.5 km (2.2 miles) from a paved highway, and 3.5 km (2.2 miles) from an operating oil well. Only 2 of the 10 nest sites used since 1966 are closer to any road than 1.6 km (1 mile). One of these, successful four times in a row, has not been used since 1969. Human disturbance at that site has increased appreciably in recent years, and may be the cause of current disuse, although there are other possibilities, such as death of one or both members of the resident pair.

Some nest sites used in past years now appear abandoned. Reasons for disuse are seldom obvious, but increased disturbance locally is a possible cause in some instances. As suggested for roost sites, I think that there is a maximum level of disturbance that condors will tolerate at a nest site. This undoubtedly varies with location, especially as related to topography, but it appears likely that condors usually will not nest within 2.4 km (1.5 miles) of regularly traveled roads or similar activity (Sibley 1969).

Even if nest sites are not permanently abandoned due to disturbance, noise and human activity may effectively thwart nesting success. Peregrine falcons subjected to repeated disturbance are thought to build up "some sort of cumulative nervousness" that may eventually lead to nest failure (Herbert and Herbert 1965). Bald eagles will stay near traditional nest sites in spite of considerable disturbance, but may not breed (Broley 1947). "Fear" reactions of various types are thought to inhibit breeding in birds, perhaps by curtailing ovulation (Marshall 1952, 1961).

It has been suggested (Moll 1969; Oehme 1969) that sonic booms may addle eggs and kill embryos, but laboratory tests indicate this is unlikely (Memphis State University 1971). Sudden loud noises have been known to frighten adult birds from the nest, however, causing them to break eggs or knock eggs or young from the nest (Ames and Mersereau 1964; Hagar 1969). Activity near nests has caused young raptors to fly prematurely, which sometimes resulted in their death or injury (Grier 1969; White 1969; Garber 1972).

Condors may not abandon nests despite repeated disturbance during the nesting cycle. Observations were made near one nest on 107 days during one nesting season, and the condors were disturbed at times by whistling, handclapping, and other human activity (Koford 1953). The young bird fledged successfully. Koford (1953) also reported instances where men actually entered the nest cave while nesting was taking place, with no apparent detrimental effects. However, broken eggs and dead chicks have been found at nests, and human disturbance has been implicated in some of these losses. For example, one nest visitor startled an incubating condor, which knocked its egg from the nest as it hurriedly departed (Sibley 1969). Two other examples that did not result in egg loss, but that show the potential, are also recorded by Sibley (1969). In the first, an incubating condor was startled by a man nearby, and in its haste to get up it kicked the egg several inches forward. On another occasion, a condor sleeping in a pothole virtually "exploded" from the cave when a sonic boom occurred, and it appeared visibly agitated for the next hour. Sibley (unpublished field notes) on two occasions was inside small nest-type caves when sonic booms occurred. He found the experience very unpleasant, and experienced considerable ringing in his ears.

Repeated disturbance of condors at nests might cause egg loss through chilling, or inadequate feeding of the young bird might result (Koford 1953). In addition, repeated disturbance during courtship might frustrate mating attempts. Sibley (1969) watched a courting pair of condors obviously disturbed by airplane traffic overhead. Each time a plane was heard, the displaying bird would fold its wings and look toward the sound, then begin again. If such interruptions were repeated regularly, courtship and subsequent reproduction might be inhibited.

Other Factors Possibly Affecting Productivity

Weather and Climate

Annual weather patterns and long-term climatic changes have been suggested as causes of reproductive variability, but the relationships are not well understood. High temperatures are known to stimulate egg laying in some instances (Davis 1955), but are thought to retard breeding in others (Sharma 1970). High humidity appears best for Indian white-backed vulture (*Gyps bengalensis*) reproduction (Sharma 1970). Humidity may also be important for the California condor, because Koford (1953) suggested that failure of three condor eggs was possibly due to the "dryness and coldness of the spring."

Within the current range of the condor, temperature and humidity vary considerably between individual nest sites every year. Certain years may be better or worse than others, but there is no obvious correlation between weather and nest success. The Northern Hemisphere has experienced a gradual warming trend since the late 1890's (Kalela 1949; Critchfield 1960; Nelson 1969), but the actual change in temperature has been small and variable from year to year (Critchfield 1960). It does not seem correlated with changes in condor reproduction since the early 1960's.

Minimum Population Density

Each population seems to have an optimum size at which it thrives best. If it falls below some minimum size, passing a certain "point of resistance" (Leopold 1933), it frequently becomes extinct (Allee et al. 1949). The mechanics of this minimum density have been described both genetically and socially. When a population has a small effective breeding number, certain genes become fixed and others lost. The population loses genetic variability, and certain nonadaptive or deleterious traits may become fixed in the population (Koford 1953). Socially, certain group activities seem necessary, in some instances, to stimulate and synchronize individual reproductive activity (Darling 1938). Also, a certain population level is necessary to insure prospective mates finding one another. For example, the population density of the rhinoceros on the Indian subcontinent is so low that it is unlikely that two rhinoceroses of opposite sex will meet and breed since they are very rare and the male's period of sexual activity is very short (Slobodkin 1961).

The genetic makeup of the California condor population is unknown, but applying the general rules of plant and animal breeding, it appears that the inbreeding coefficient may well be high enough to adversely affect reproduction (R. W. Allard, personal communication). Fortunately, species in which population size has never been large are frequently more resistant to inbreeding than other species, presumably because their genetic system evolved under some low level of inbreeding. That the whooping crane (*Grus americana*) population was able to increase even after numbers had fallen below 20 birds (McNulty 1966) is cause for hope that condor genetic makeup has not been irreparably affected. The cranes, however, continued to produce at a favorable rate even at the population's lowest point; the condors have not.

Although condor numbers, disparities in sex ratio, and isolation of subpopulations may combine to limit the number of pairs that can be formed, the effects of social stimulation are not so evident. Not all species require communal stimulation to release breeding behavior (MacRoberts and MacRoberts 1972), and the condor appears to be one that does not. Condors nesting successfully in San Luis Obispo and Santa Barbara counties have been completely isolated from other nesting condors, and seldom even join with others for feeding or roosting. In the Sespe Condor Sanctuary, I have observed pairs courting in company with other condors, but have never seen evidence that other pairs were stimulated by the display. Koford (1953) reports a similar lack of interaction between courting birds and others in the group.

Senescent Adults

If productivity ceases or declines with age, then a preponderance of old birds may not be breeding. Hickey (1942) suggested this as a cause of reproductive failure in peregrine falcons and California quail (*Lophortyx californicus*). It has also been hypothesized that, even if age does not bring sterility in peregrines, it may result in less success due to smaller clutch size, less intensive brooding, weakened attachment to the nest, and decreased capacity for finding food (Kleinstauber 1969).

The few definite available records of duration of breeding in raptors indicate senescence may not be a significant problem. Wild peregrines are known to have reproduced when at least 18 and 20 years of age, and a golden eagle in captivity laid eggs until it was 30 years old (Herbert and Herbert 1965). A captive California condor laid eggs until 32 years old (Koford 1953). However, if aging is a problem, it would be most likely in a species like the condor where individuals normally reach advanced age.

Insufficient Nest Sites

Koford (1953) lists the main physical requirements of a condor nest site as a cavity, usually in rock but in one instance in a tree, with: (1) suitable adult roosting perches nearby; (2) fairly easy approach from the air; (3) space below for taking off; (4) protection from storms, wind, and direct sun; (5)

space enough inside to hold two full-grown adults; (6) a level, sandy spot on which to lay the egg; and (7) perches nearby for the young bird after it leaves the nest. Adding these requirements to the need for relative isolation, and a strong preference for traditionally used nest sites, it becomes apparent that there are only a few areas where condors are likely to nest. Despite these requirements, there seems to be no current shortage of nest sites within the limited habitat available.

California condors apparently do not defend a large nesting territory. Altercations between nesting birds and other condors are seldom seen, even though large numbers of nonbreeding birds have roosted close to active nests (Koford 1953), and active nest sites have been located within 1.6 km (1 mile) of one another. In 1946 and again in 1967, three active nests were known within a 7.75-km^2 (3-square-mile) area (F. C. Sibley, unpublished field notes). That particular area still appears physically suitable for that concentration of birds, and there are many other historically used sites within the current range of existing subpopulations that are not now occupied. If, as seems likely, the condor does not require more nesting territory than the 0.8 to 1.6 km (0.5 to 1 mile) estimated for other large raptors (Broley 1947; Vernon 1965; Grier 1969), there should be physical space for many more pairs to breed. Location of food near nest sites may, of course, be limiting.

Pesticides and Air Pollution

Poisoning has probably been a minor cause of California condor mortality but pesticides and other noxious substances are known to react in sublethal fashion in some species, reducing productivity and impairing individual vigor (Stickel 1975). Organochlorine compounds can cause death if weight loss resulting from reduced food intake, reproductive activity, or injury causes lethal mobilization of chemical residues stored in body fat (Van Velzen et al. 1972).

The effects of pesticidal contamination on California condors are unknown, but evidence is accumulating that there may be adverse relationships.

Body Residues

An immature condor that died after colliding with a power line in May 1965 had visceral fat concentrations of 18 ppm p,p'DDT and 30 ppm p,p'DDE (Hunt 1969). The bird had a full crop, was in good condition, and weighed a normal 8.74 kg (19.25 pounds; California Department of Fish and Game, unpublished report).

A second immature condor, found dead and considerably decayed in November 1974, had leg muscle concentrations of approximately 50 ppm p,p'DDE, plus much smaller amounts of other organochlorines (Patuxent Wildlife Research Center, unpublished report).

An adult female condor died in November 1976 after suffering a gunshot wound in the wing. At death it weighed only 6.04 kg (13.3 pounds). A sample of flesh contained 12 ppm p,p'DDE, and fatty tissue had 105 ppm p,p'DDE plus low amounts of several other organochlorines (Patuxent Wildlife Research Center, unpublished report).

Species differ markedly in their reaction to pesticides, so no firm conclusions can be drawn concerning the significance of these levels in the condor. In the first instance, the levels are relatively low, since residues in fat in a bird in good condition generally will be 10-20 times those in the total body. The levels in the adult bird were higher, but perhaps not unusual or unexpected for a bird that was in such poor nutritional condition. However, in comparison with other species, it seems possible that the concentrations found in the 1974 immature bird might have been enough to adversely affect reproduction in a mature bird or even cause death if fat mobilization occurred.

Eggshell Changes

The difference in pre-1944 mean condor eggshell thickness (0.79 ± 0.02 mm) and post-1963 thickness (0.54 ± 0.02 mm) is 31.1% (L. F. Kiff, D. B. Peakall, S. R. Wilbur, and R. L. Garrett, in preparation). This difference is both biologically and statistically highly significant. The thickest eggshell in the post-1963 sample was 23% thinner than the pre-1944 mean; the thinnest post-1963 specimens were 56.9% thinner than normal. Thinning of 20% or more is likely to result in reproductive failure and population decline (Stickel 1975). In nearly every study of eggshell thinning, DDE has been thought to be the major cause (Stickel 1975).

In addition to thinning, California condor eggshells collected since 1963 show abnormal internal structure. In photographs taken with a scanning electron microscope, a decreased porosity and an unusual compactness are evident (L. F. Kiff, D. B. Peakall, S. R. Wilbur, and R. L. Garrett, in preparation). This structural pathology is similar to that produced in eggs contaminated with chlorinated hydrocarbon pesticides (McFarland et al. 1971). Most of the post-1963 eggs on which measurements were made were found broken in the nest.

Although significant contamination is suggested by the above, a logical source of contamination has not been discovered. In general, concentrations of pesticides in condor food items are believed to be low. It may be that vultures metabolize pesticides differently than other groups of birds, resulting in greater concentrations. Turkey vulture eggshells have not thinned as much as condor eggs have, but they are 11-12% thinner than those collected before 1947 (S. R. Wilbur, in preparation). Andean condors collected in Peru had much higher concentrations of chlorinated hydrocarbons than other local species including the brown pelican (*Pelecanus occidentalis*), a species known to concentrate pesticides (D. W. Anderson, personal communication). In contrast, golden eagles, with a food source similar to condors, have shown no significant eggshell thinning (Hickey and Anderson 1968) or bodily concentration of pesticides (Reichel et al. 1969).

Effects of air pollution on birds have not been examined, but some detrimental effects have been found among mammals (Statewide Air Pollution Research Center 1973). The very rapid flow rate of air through the complex system in the body of the bird in flight suggests the possibility of undesirably high exposure. No monitoring of organochlorines or other air pollutants has been done in the vicinity of condor nests and roosts, but topographical and meteorological considerations suggest that air pollution levels may be high in these sites (P. C. White, personal communication).

Preservation

The California condor is immediately threatened with extinction, so threatened that the future of the species may well be decided within the next few years. If production fails to increase, and if annual mortality remains constant or increases over current levels, the species that has defied so many predictions of doom will at last disappear. The difference between the past and present is simply this: although the condor population has been declining gradually for many years, until recently numbers were high enough and production great enough that production deficits were low and the decrease was slow. This is no longer true. Currently production is low in a very small population whose average age increases yearly. Major losses due to old age could occur at any time, further reducing the population's potential for survival.

Although recommendations have been made for preservation of the condor (Koford 1953; Miller et al. 1965; Mallette 1970; Carrier 1971), and many have been implemented, the condor continues to decline. Past action was not wrong (had it not been for protection and management accomplished to date, the situation could be much worse), but it was not enough. While one problem was being treated, other factors continued to operate against the population. A comprehensive effort to attack all possible limiting factors simultaneously has been urgently needed.

The California Condor Recovery Plan

Steps to achieve this overall approach to condor preservation were taken with the preparation and implementation of a California condor "recovery plan" (California Condor Recovery Team 1974), the prime objective of which is stated as:

> To maintain a population of at least 50 California Condors, well distributed throughout their 1974 range, with an average natality of at least 4 young per year, and with the lowest possible mortality.

The basic tenets of the Plan are: (1) if condors are well distributed geographically so that all are not subject to the same local limiting factors and catastrophes; and (2) if annual production equals or slightly exceeds expected annual mortality rates, then a small population of California condors can continue to survive. The species would still be "endangered," but with continued intensive management, could become stabilized.

The Recovery Plan recognizes three principal needs of the condor population: adequate nesting sites, suitable roosts, and feeding habitat with adequate food. These must be available to each subpopulation of condors, and must be geographically and seasonally located to accommodate traditional condor use patterns.

Nesting Requirements

All nest sites known active within the past 20 years are on National Forest lands, and a plan for their protection has been prepared and implemented by the U.S. Forest Service (Carrier 1971). Two basic objectives are: (1) to restrict all motorized activity and blasting within 2.4 km (1.5 miles) of each condor nest site; and (2) to locate trails and trail camps out of direct line-of-sight of nest sites within a 0.8-km (0.5-mile) distance, and to continue restriction of the Sespe and Sisquoc Condor sanctuaries to all public use.

In general, the Forest Service has authority to manage National Forest lands for endangered species. However, administration of mining and mineral resources rests with the U.S. Department of the Interior. Restriction of such activities requires action by the Bureau of Land Management. Expanding oil development is now a major threat to nesting habitat.

Aircraft activity in the vicinity of nests may discourage condor use and may indirectly result in nest failure. A 914-m (3,000-foot) terrain clearance over nesting areas is now recommended on military and civilian flight maps, and the air space over the Sespe Condor Sanctuary is legally closed (Section 10501.5, California Fish and Game Code).

The value of all restrictions is increased by an active, well-rounded program of education, patrol, and law enforcement. Educational emphasis should center on the plight of the bird, and the justification for restricted use of nesting areas. Patrol will reduce the potential for violation of closures, and diligent law enforcement will act to deter further trespass in closed areas. As the condor requires the entire year to complete its reproductive cycle, restrictions should be in effect at all times.

Condors cannot breed without adequate nest sites, but production is apparently being limited by some other factor or factors. Inadequate food supply has been shown to result in reproductive inactivity in many species, and is believed to figure significantly in the decline of carrion-eating birds in South Africa (Houston 1971), Spain (de la Fuente 1964), and elsewhere. Supplemental feeding programs for vulturine birds have been initiated in Spain, France, Sardinia, and Austria (Bijleveld 1974). Our own experiences with an experimental feeding program for California condors show that condors will feed at bait stations without congregating in unnatural numbers or losing their "wildness" (Wilbur et al. 1974). Such feeding should be continued on a yearlong basis as long as there is any possibility that it is worthwhile.

There is enough evidence of chemical contamination of condors and their habitat to warrant a thorough evaluation of the effects of pesticides and air pollutants. The identification and removal of sources of contamination should be given high priority, as should laboratory studies of the effects of toxic chemicals on vulture reproduction and well-being.

Roosting and Feeding

Roosts are located on National Forests, and other Federal, State, and private lands. The U.S. Forest Service objective for protection of roosts is to eliminate all human activity within at least 0.8 km (0.5 mile) of the roosts (Carrier 1971). The same basic objective should be pursued for condor roosts on non-Forest Service properties.

Most feeding areas are on private lands. The basic need is to keep adequate food available in a relatively disturbance-free environment at those times of year that condors frequent any given area. A yearlong food supply is needed near nesting areas; elsewhere, requirements are seasonal. Preservation of food supply and feeding terrain near well-established nests and roosts should receive greatest emphasis. This may require outright purchase of key parcels, cooperative land-use agreements, and supplemental feeding. County zoning and land-use restrictions can often be made to favor the condor if they maintain open space and rangeland agriculture.

Protection from Mortality

Shooting, disruption of nesting activity, and possibly poisoning have the greatest potential for causing condor mortality. Mortality at nests will be limited by implementation of nest protection measures. Potential for shooting losses can be reduced by increased education, patrol, and law enforcement, and by firearms regulations and restrictions in certain condor congregation areas. The condor is legally protected by State and Federal law. The threat from toxicants can be reduced through cooperative planning of animal control programs, limiting extent, location, and timing to have least potential impact on condors.

Full and immediate implementation of the Recovery Plan seems to me to be a minimum requirement for perpetuation of the California condor. Without that, habitat for the condor will continue to shrink in size and quality, further limiting survival potential. Although much effort has been directed toward preserving the condor during 1965-76, there are no signs of increased stability within the population. In fact, a significant decrease in production has occurred, and total numbers have declined during the last 10 years. I think that it is unlikely that the California condor can be perpetuated by only those relatively conventional procedures outlined in the Recovery Plan. Without interrupting action on the Recovery Plan, I recommend concurrent implementation of two additional measures: (1) establishment of new nesting areas, and (2) captive propagation.

New Nesting Areas

There are enough suitable nest sites for many more pairs of condors than have nested recently, but as mentioned earlier, condors have begun to congregate in an area well removed from traditional nesting habitat. One objective of supplemental feeding was to maintain and reinforce existing ties between breeding and nonbreeding areas. So far, this has not occurred. An alternative is to provide nest sites in the currently favored area in Kern County, an area that seems well adapted to yearlong condor occupation except that it lacks cliffs and caves for nesting. Structures made of artificial stone, such as are commonly used in captive animal displays, could be erected in isolated canyons in the Tehachapi Mountains away from most human access. Nest boxes have apparently not been used by vultures and might not be accepted by condors, but their provision would give the population one more option for survival.

Captive Propagation

At best, recovery of a totally free-living California condor population will be very slow. One method of accelerating population growth involves capturing several pairs of condors, holding them in captivity for breeding, and subsequently releasing their progeny to the wild. The condor's long period of sexual immaturity and inherently low reproductive rate are liabilities in such a program, but condors appear to do well in captivity and, barring accident or disease, can be expected to live many years. California condors have never been produced in captivity, but the Andean condor, in many respects much like the California species, has bred regularly in captivity (Janda 1939; Portielje 1949; Lint 1960; Olivares 1963; Poulsen 1963; Dekker 1967; Erickson 1974). Griffon vultures, similar in size and overall breeding characteristics to the California condor, have also bred and reared young in captivity (Bouillault 1970). In considering the opportunity to accelerate condor production, experiences with Andean condors at San Diego Zoo (San Diego, California) are especially noteworthy. In 10 years, one pair of Andean condors produced nine young, eight of which survived (Lint 1960). Rearing young away from the parents and hatching some eggs in incubators encouraged the adults to renest more often than they would have otherwise. A wild pair could have produced a maximum of only five young in the same time period.

Although capturing condors will reduce the size of the wild population, and might further reduce its breeding potential, apparently only a few pairs of condors are now responsible for the productivity of the entire population. Condor trapping could be timed and located to minimize the likelihood of capturing current breeders. Actual numbers in the wild would be reduced, but this would not necessarily reduce the reproductive potential of the population.

Objectors to captive propagation cite the lack of results in reestablishing captive reared birds in the wild. Admittedly much more research is needed but current projects involving peregrine falcons, bald eagles (*Haliaeetus leucocephalus*), whooping cranes, Aleutian Canada geese, (*Branta canadensis leucoparela*), and other endangered species have already produced results that are applicable to a California condor reestablishment program. Once Andean condor propagation techniques are perfected, release back to their native habitat is anticipated (Erickson 1974). All things considered, it seems likely that, by the time California condors are available for release to the wild, reestablishment procedures will have reached an advanced state.

Can the Condor Be Saved?

Because the California condor has survived so many predictions of imminent extinction, it would be comforting to assume that the species will go on forever no matter what. Complacency is nurtured by the almost certainly false belief of some that condors have been rarer and in worse circumstances in the past than they are now. The reasoning goes that if they have "saved themselves" before, they can do it again. Actually, consideration of the species' reproductive potential and the known losses since the turn of the century must lead to the conclusion that significant gains in population size were not only unlikely, but were nearly impossible.

McMillan (1968:42) stated that "there is considerable evidence that the entire species was close to extinction around 1908 . . . perhaps closer to extinction that at any time before or after." The discussion does not include an estimate of the population size, but McMillan and co-workers estimated that there were only 40 condors in 1965 (Miller et al. 1965). If the population was as endangered in 1908 as it was in 1965, then there were probably no more than 40 birds and possibly fewer. If there were only 40 birds in 1908, and if Koford's (1953) estimate of 60 birds in 1950 was accurate, then the population increased by 50% in 42 years. In addition to production needed to keep the population size stable, an average addition of one new bird every 2 years would have been required.

As discussed in the section on production, condors are probably not reproductively active until they are 8 or more years old. In a small population there are almost certainly uneven numbers of males and females. Because of the wide geographical range occupied by condors, probably not all condors have the opportunity to meet and mate. Finally, there may be adults in the population that have passed reproductive age. Considering all these factors, a population of 40 condors could include no more than five to six breeding pairs. Condors do not usually nest every year, so the highest annual production for so small a population would be two to three young.

Koford (1953) estimated 15-20 subadult condors (i.e., those in various subadult plumages) in his population of 60. Considering that other condors were incapable of forming pairs for the reasons outlined above, there could have been about 15 adult pairs. Assuming biennial nesting, seven to eight nestings per year would have been possible.

Starting with only two to three pairs laying eggs each year, population increase would have been slow initially. A possible progression would have been: 1908-21, three young per year produced; 1922-33, four young; 1934-40, five young; 1941-46, six young, and 1947-50, seven young. The maximum production at those rates would have been approximately 200 condors, but long-term "biological maximum" is never reached in a wild population. In the condor population, 50% success may be near the norm (F. C. Sibley, unpublished progress reports). Assuming a more optimistic 75% nest success, only 150 condors would have been produced between 1908 and 1950.

In that same 42-year period, a minimum of 17 condor eggs were taken from the wild, and a minimum of 55 condors died from various causes (Appendix II). Actual loss is unknown, but Koford (1953) assumed 5 to 10% annual mortality for the California condor under natural conditions. If losses to accidents, old age, and other "natural" factors averaged 5% annually, then 100 condors would have died in addition to the unusually high human-caused losses during that period. A mortality of over 150 condors is almost certain, so no increase could have occurred.

Much of the above is hypothetical, but based on what is known about condor history and population dynamics, the analysis is not unreasonable. Substituting other numbers and percentages will not change the conclusion that the California condor population does not have the capacity for significant increase now, and even more certainly did not have it during the early years of the 20th Century when mortality was abnormally high.

I agree with Koford (1953) that the California condor is most pleasing symbolically and esthetically as a free-flying, self-perpetuating species, but each passing year brings more questions about its ability to survive without intensive management. Since the passing of the wild big-game herds and their replacement with livestock in the mid-1800's, the condor has been dependent on the activities of man, and "naturalness" has been relative. Nevertheless, the wildness that is left in the species is desirable and should be preserved. If the species can be saved, we should also be able to preserve the aura and tradition of condor and condor habitat. It is not necessary to sacrifice "wildness" for "management."

The California condor is on the brink of extinction right now, and may disappear no matter what we do. If the species is to be saved, it must receive our most innovative attention as quickly as possible.

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APPENDIX I

Record of Condor Occurrence, 1966-1976

The following list includes representative records of California condor distribution and numbers during 1966-76. These sightings, plus additional similar records totaling 3,045 observations, are the basis for the range delineations and population estimates in the present report. All these records are regarded as "positive" (i.e., there is little or no chance that they do not represent condors in the numbers and ages listed). An additional 520 sightings, many of which undoubtedly were valid reports, were excluded from the analysis because not enough information was provided, the ability of the observers was unknown to me, or for other reasons. All 3,565 records are on file with the U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland.

Abbreviations used in the list are: A, adult birds; I, immature plumaged birds (under about 5 years old); U, birds unclassified to age. Initials of regularly cited observers are: KA (Keith Axelson), JB (John Borneman), DC (Dean Carrier), DCo (David Connell), GS (Grace Corlis), HC (Harold Cribbs), EF (Evalyn Farnsworth), RF (Reno Ferrari), WF (Walter Fieguth), HH (Harry Hayden), DM (Don McLean), MM (Monty Montagne), RM (Robert Mallette), DO (Dan O'Connor), CO (Clyde Osborn), RP (Riley Patterson), PR (Pauline Roulier), DS (Dick Smith), FS (Fred Sibley), IS (Ina Singer), MS (Martin Steiginga), MSl (Mike Silbernagle), SS (Sandra Southard), HU (Hazel Upham), NW (Mrs. J. B. Williams), RMW (Russell and Marion Wilson), SW (Sanford Wilbur), and TZ (Tony Zufich).

Santa Clara County

1966, San Jose: 26 Oct., 2A 1I (DM).
1967, San Jose: 10 Nov., 1I (DM).
1968, San Jose: 23 May, 1A (DM); 26 Oct., 2A (DM).
1970, San Jose: 3 Sept., 1A 1I (DM).
1971, Palo Alto: 10-12 Jan., 1I (H. Mundy, W. Anderson).
1971, San Jose: 28 Sept., 1A 2I (DM).
1972, Palo Alto: 4 March, 1A (G. Meyers).
1972, Pacheco Pass: 1 June, 2A 1I (W. Goodloe).

San Benito County

1967, Quien Sabe Ranch: Feb., 1U (G. Haganen).
1968, Call Mountain: 8 Sept., 2A (F. Williamson).

Monterey County

1970, Cone Peak: 25 Oct., 1U (P. Kinder).
1971, Pacific Grove: 28 Jan., 1A (T. Robinson).

1971, Cone Peak: 22 May, 1A (P. Kinder).
1971, Parkfield: 28 Sept., 2A (J. Edwards).
1973, Parkfield: June, 1A (B. Walton).
1975, Hunter-Liggett Military Reservation: 31 March, 1U (L. Sitton)

Kings County

1970, near Avenal: 3 Sept., 2U (J. Traub).

San Luis Obispo County

1966, Lopez Canyon: 7 Feb., 3A (E. Barbere, D. Peton); 21 April, 1A (E. Barbere).
1966, Hi Mountain: 1 March, 1U (R. Stone); 30 Nov., 2A 1I (FS, JB).
1966, Pozo: 15 March, 1A (R. Stone, J. Blake).
1966, Cholame: 9 Sept., 1A (E. McMillan).
1966, Black Mountain: 22 Sept., 1A (V. Livingston).
1967, Garcia Mountain: 10 Jan., 1A 1I (J. Blake); 14 Feb., 1I (J. Blake).
1967, Hi Mountain: 24 May, 1A 1I (FS); 14 Sept., 1I (FS); 11 Oct., 1A (RF).
1967, Lopez Lake: 26 July, 1U (C. Edon).
1968, Beartrap Canyon: 6 March, 2A (FS, E. McMillan).
1968, Pozo: 13 April, 1A (J. Blake); 31 Aug., 1A (H. Martin); 12 Sept., 2A (J. Blake).
1968, La Panza: 3 May, 1A (L. Todd).
1968, Hi Mountain: 31 May, 1A (RF); 16 June, 1I (RF); 30 July, 1A 1I (FS, DC); 17 Oct., 3A 1U (RF, J. Edwards); 20 Oct. 2A 1I (RF); 4 Nov., 2A (RF); 20 Nov., 2A 1I (FS, DC); 10 Dec. 2A 1I (RF).
1969, Lopez Canyon: 29 Jan., 1A (V. Price, B. Doan).
1969, Fitzhugh Ranch, Villa Creek: 1 April, 1I (A. Fitzhugh); 16 April, 1A 1I (L. Fitzhugh).
1969, Cholame: 27 April, 1U (R. Garrett); 22 June, 2U (R. Gilman).
1969, Simmler: 8 May, 1A (RP).
1969, Beartrap Canyon: 18 June, 1A (FS).
1969, Hi Mountain: 12 July, 2A (RF); 1 Aug., 1I (RF); 26 Nov., 2A 1I (RF); 12 Dec., 2A 1I 2U (RF).
1969, Carrizo Plains: 18 Aug., 2A 2I (E. McMillan).
1969, Rocky Butte: 22 Aug., 1A (B. and H. Robe); 22 Sept., 2A (B. and H. Robe).
1969, Black Mountain: 25 Aug., 1A (J. Gregory).
1970, Pozo: 27 Feb., 1A (J. Blake).
1970, Hi Mountain: 13 March, 1A 1I (DC, SW).
1970, Beartrap Canyon: 27 March, 1A 1I (S. and S. Wilbur).
1970, Palo Prieto Canyon: 29 May, 2U (R. Gilman).
1970, Rocky Butte: 10 Aug., 2I (B. and H. Robe).
1970, Cholame: 19 Oct., 1A (G. Tidwell).
1970, Morro Bay: 27 Dec., 1I (J. Edmisten).
1971, Simmler: 3 Jan., 1A (T. Huff); 5 May, 1A (C. Edon).
1971, Garcia Mountain: 7 Jan., 1A (R. Rominger).

971, Los Machos Hills: 1 March, 2A 1I (W. Baden).
971, Hi Mountain: 4 Aug., 2A 1I (V. Price); 15 Dec., 1I (J. Sutter).
971, Rocky Butte: 15 Aug., 1A 2I (H. Robe).
972, Shandon: 20 March, 2A (E. McMillan).
972, Elkhorn Valley: 27 April, 1A (R. Thomas).
972, Branch Mountain: 15-16 Oct., 1A (R. Reghetti, S. Rollins); 28 Oct., 1I (S. and W. Rollins).
973, Pozo: 2 Feb., 2A (D. Cooper).
973, Hi Mountain: 28 May, 2A (J. Conway).
973, Wilcox Canyon: 6 June, 1A (G. Rhoden).
973, Beartrap Canyon: 23 July, 2A 1I (B. Walton).
973, Lopez Canyon: 17 Nov., 1A 2U (J. Conway).
974, Pilitas Mountain: 14 Feb., 4A (C. Koford).
974, Hi Mountain: 22 Dec., 1I (J. Gabel).
975, Pozo Station: 8 March, 1U (J. Arnold).
975, Hi Mountain: 11 July, 2U (A. Sims).
975, Los Machos Hills: 12 Nov., 1A (J. Arnold).
976, Carrizo Plains: 10 Jan., 2A 1I (R. Palm).
976, Temblor Mountains: 8 June, 1A 3U (D. Bowman).

Santa Barbara County

966, Los Alamos: 12 Jan., 2A (JB).
966, San Marcos Pass: 6 April, 2A 1I (J. Mills).
966, Bluff Camp, Buckhorn Road: 21 May, 2A (W. Hansen); 21 Sept., 2A (JB).
966, Buellton: 31 May, 2A (RP).
966, Cuyama Peak: 3 June, 1I (B. Hudson); 23 June, 1A (B. Hudson); 13 July, 1I (B. Hudson); 18 Oct., 1A (B. Hudson).
966, Pendola: 9 June, 1A (B. Harvey).
966, Manzana Creek: 12-15 June, 1U 4U (F. Winter, J. Lorenzana).
966, Figueroa Mountain: 3 July, 2A (HH); 30 July, 1I (HH).
966, Sierra Madre Ridge: 18 Oct., 2A (F. Thayer, DS).
966, La Carpa Potreros: 15 Dec., 1A 3U (D. Calkins).
967, Cuyama: 15 Jan., 2A (E. Morris).
967, Pendola: 18 Feb., 1U (DS).
967, Sisquoc Condor Sanctuary area: 27 Feb., 2A (DS); 1 March, 2U (DS): 18 Oct., 2A (DS, W. Griffin).
967, Figueroa Mountain: 24 March, 2A 1U (C. Smith); 9 Oct., 1A (HH); 4 Nov., 2A (B. Schram).
967, McPherson Peak: 23 July, 1U (L. Jordan).
967, Monte Arido: 25 Aug., 1A (FS, JB).
967, Cuyama Peak: 18 Oct., 1A 1I (D. Jorgensen).
967, Los Olivos: 29 Nov., 2A (DS).
967, Sierra Madre Ridge: 12 Nov., 2A (R. Dias); 16-17 Nov., 1A (FS); 4 Dec., 2A (R. Dalen).
968, Montecito Peak: 8 Jan., 1I (M. Sanchez, G. Davidson).
968, Sisquoc Condor Sanctuary: 7 Feb., 1A (DS); 12 Aug., 2A (R. Dias, A. Simas); 21 Oct., 1I (A. Simas).

1968, Madulce Peak: 23 March, 1I (H. Buck).
1968, Sierra Madre Ridge: 8 May, 2A (DCo, E. Morris); 23 Oct., 2A (DC, DCo).
1968, McPherson Peak: 3 July, 1I (W. Conrad); 24 Oct., 2A (A. Conrad).
1968, Santa Ynez: 30 July, 1A (G. Adams).
1968, Cuyama Peak: 2 Oct., 1A 1I (V. Lacy); 3 Oct., 3A (V. Lacy); 24 Oct., 2I (V. Lacy).
1968, Figueroa Mountain: 29 Oct., 1U (HH); 5 Dec., 2A (HH).
1969, Sisquoc Condor Sanctuary: 10 Jan., 1I (D. Moody, R. Dias); 1 April, 2A (J. Easton); 15 Oct., 2A (DS, R. Dalen).
1969, Madulce Peak: 30 Jan., 1A (D. Enger, J. Oman); 1 June, 1A (W. Hansen).
1969, Figueroa Mountain; 2 Feb., 1A (J. Baker); 21 May, 1I (HH); 12 Aug., 1A (HH); 9 Oct., 1A (HH).
1969, Bluff Camp — Buckhorn Road: 14 May, 2A 2I (B. Doan, T. Thompson); 31 Dec., 3U (R. Talbot, D. Shields).
1969, McPherson Peak: 19 May, 2U (D. Moody).
1969, Santa Barbara Potrero: 7 July, 2A (DCo).
1970, Sierra Madre Ridge: 8 Jan., 2U, (M. Sims); 3 June, 1U (M. Sims); 9 Aug., 1A (M. Sims); 12 Sept., 1A (M. Sims).
1970, Manzana Narrows: 30 Jan., 2A (E. Kynoch).
1970, Los Prietos: 16 March, 2A (R. Calkins).
1970, Sisquoc Sanctuary: 22 March, 1A (D. Thompson); 27 March, 2U (J. Miller).
1970, Figueroa Mountain: 13 Aug., 1U (HH); 10 Nov., 1U (HH); 3 Dec., 1A (W. Stevens).
1970, Buellton: 5 Sept., 1A (J. Sinton).
1971, Los Alamos: 22 Feb., 2U (T. Monighetti).
1971, Sisquoc Condor Sanctuary: 27 April, 3A (M. Sims); 10 May, 2A (W. Alexander); 9 June, 2A (M. Sims).
1971, McPherson Peak: 23 May, 2A (W. Conrad); 14 Aug., 1A (W. Conrad).
1971, Lake Cachuma: 26 Feb., 1A (I. McMillan).
1971, Cuyama Peak: 19 June, 1A (A. Sims); 3 July, 1I (A. Sims); 8 Nov., 2A (A. Sims).
1971, Figueroa Mountain: 23 Oct., 1A (HH).
1972, Madulce Peak: 4 March, 2A (DS, J. Berry).
1972, Sisquoc Sanctuary: 30 March, 1I (A. Sims).
1972, Sierra Madre Ridge: 3 June, 1A 1I (B. Holdridge); 20 Aug., 1A (DS).
1972, Cuyama Peak: 13 Aug., 2A (G. Carpenter); 1 Sept., 1U (G. Carpenter).
1972, Cachuma Mountain: 27 Aug., 2A (P. Flores).
1972, Figueroa Mountain: 27 Dec., 1A (J. Sutter).
1973, Cuyama Peak: 24 June, 1U (D. O'Connor); 19 July, 1I (D. O'Connor); 7 Oct., 1A (D. O'Connor).
1973, Sisquoc Sanctuary: 23 Feb., 1U (DS).
1973, Sierra Madre Ridge: 6 July, 1A (DS).
1973, Figueroa Mountain: 31 Aug., 1A (H. Greiman).
1974, Sisquoc Sanctuary: 12 April, 1A (L. Mansfield).
1974, Cuyama Peak: 30 May, 1I (K. Allen); 12 July, 1A (K. Allen); 7 Oct., 1A (K. Allen).

1974, Bluff Camp — Buckhorn Road: 10 Oct., 1A (DS, L. Kinnear).
1974, Zaca Mountain: 29 Nov., 1A (R. Easton).
1975, Sisquoc Canyon: 16 Feb., 3A (W. Hansen).
1975, West Big Pine: 27 Feb., 2A (MM, DS); 2 April, 3A (MM, DS); 13 May, 3A 1I (MM, DS); 5 June, 3A (DS, SW); 22 July, 2A (MM); 21 Oct., 1A (MM, DS).
1975, Hurricane Deck area: 8 April, 1A (J. Cody).
1975, Cuyama Peak: 27 May, 1U (J. Black); 15 July, 1A (J. Black).
1976, West Big Pine: 9 Jan., 2A (MM, DS); 22 April, 1A (J. Hamber, DS); 15 June, 2A (MM, DS); 13 July, 2A 1I (MM, DS); 18 Nov., 2A 1I (MM, DS).

Ventura County

1966, Topatopa Bluffs: 5 Jan., 2A (JB).
1966, Hopper Canyon area, Sespe Condor Sanctuary: 25 Jan., 9A 1I (JB); 2 Feb., 13A (FS, JB); 10 Feb., 2A 6U (JB, Y. Miller); 12 April, 2A 1I (JB); 17 May, 3A 2I (JB); 19 July, 3A (JB); 19 Oct., 1I (DCo); 24 Dec., 2A 2I (DCo).
1966, Bucksnort area, Sespe Condor Sanctuary: 5 March, 5A 1I (JB, Y. Miller); 17 March, 6A (G. Morgan); 20 April, 6A 1I (Y. Miller); 4 July, 4A (JB); 7 Oct., 2A (JB).
1966, Ozena: 8 Feb., 2I (HU).
1966, Gold Hill: 9 Feb., 2A (JB).
1966, Santa Paula Canyon: 16 Feb., 1A (JB).
1966, Sespe Hot Springs: 22 March, 6A (JB, FS); 4 Oct., 1A (FS).
1966, Mutau Flat: 23 March, 1A (A. West).
1966, Frazier Mountain: 1 April, 1A 1I (V. Osborn); 29 June, 1A 1I (HU); 2 July, 3A 1I (HU); 9 Sept., 5A (HU).
1966, Matilija Creek: 13 May, 1A (S. Flores); 25 Nov., 1A (JB).
1966, Mt. Pinos: 22 July, 8A (RMW); 8 Aug., 16A (RMW); 12 Aug., 21A (JB); 25 Aug., 18A 2I 1U (FS); 3 Sept., 5A 3I (DS).
1966, Thorn Point: 14 Aug., 2A (TZ); 10 Sept., 1A (JB, FS).
1966, Reyes Peak: 18 Nov., 3U (J. Hunter).
1967, Hopper Canyon: 10 Jan., 7A 1I (FS); 23 Jan., 6A 4I (FS); 7 Feb., 6A 2I (JB, FS); 8 March, 9A 1I (DCo); 28 April, 4A 1I (FS, JB); 4 May, 6A 1I (FS); 19 June, 2A 1I (JB); 21 June, 6A (FS); 12 July, 1A (JB, FS); 28 Nov., 5A (FS).
1967, Potrero Seco: 5 Feb., 1A (B. Stone).
1967, Matilija Creek: 8 Feb., 1A 1I (JB, FS); 26 Feb., 3A (J. Lorenzana); 2 March, 2A (FS).
1967, Agua Blanca: 2 March, 8A (JB); 11 May, 2A (FS); 27 Dec., 2A (JB).
1967, Coldwater Canyon — Sespe Creek: 27 March, 2A (FS); 11 May, 1A (FS); 7 Sept., 2A (JB).
1967, Chismahoo area: 18 May, 6A (D. Adams, C. Hall).
1967, Thorn Point: 23 May, 1A (JB); 25 July, 2A 1I (TZ); 16 Aug., 1A (TZ).
1967, Nordhoff Peak: 19 June, 2A (M. Woodmansee).
1967, Reyes Peak: 22 June, 1A (JB); 18 Oct., 2A (J. Doman, G. Durney).
1967, Frazier Mountain: 23 June, 2A (HU); 9 Aug., 3A 2I (HU); 18 Aug., 8A (HU); 11 Oct., 3A (HU).

1967, Mt. Pinos: 8 June, 1A (O. Widmann); 23 July, 7A 2I (B. Watson); 17 Aug., 23A (JB); 19 Aug., 16A 3I (FS, JB); 2 Sept., 3A (B. Watson).
1967, Topatopa Bluffs: 15 Nov., 1A (JB).
1967, Santa Paula Canyon: 5 Dec., 1A (JB).
1968, Lake Piru: 6 Jan., 2A (T. Turner, A. Moreno); 8 April, 4A (A. Moreno).
1968, Matilija Creek: 18 Jan., 1A (JB).
1968, Hopper Canyon: 30 Jan., 3A (FS); 27 March, 6A (JB); 19 April, 3A 1I (G. Roby); 10 May, 3A 1I (FS, JB); 1 July, 1A (FS, DC); 6 Sept., 4A (FS, DC); 15 Oct., 1A 2I (G. Roby).
1968, Bucksnort area: 20 Jan., 4A (Y. Miller); 16 Oct., 4A (O. Widmann, C. Rust); 16 Dec., 6A 1I (JB); 17 Dec., 8A (FS, RM); 20 Dec., 13A (DC).
1968, Reyes Peak: 5 Feb., 1A 1U (M. Faaborg).
1968, South Mountain: 19 Feb., 1A (RP).
1968, Agua Blanca: 23 April, 2A (JB); 17 May, 2A (FS); 20 June, 2A (DC); 25 Nov., 2A (JB).
1968, Big Mountain — Torrey Canyon: May, 1A (D. Partridge).
1968, Mt. Pinos: 14 May, 1A (B. Glading); 6 July, 2A (B. Watson); 13 July, 6A (B. Watson); 10 Aug., 7A 1I (JB); 29 Aug., 10A 2I (FS); 16 Oct., 1A (G. Nixon, A. Fries).
1968, Thorn Point: 21 May, 1A (TZ); 28 May, 2A 1I (FS); 4 July, 2A (TZ); 11 Oct., 1A (TZ).
1968, Frazier Mountain: 5 June, 2A (HU); 17 June, 1I (HU); 1 Sept., 1I (HU); 17 Oct., 3A (HU).
1968, Nordhoff Peak: 7 June, 1I (M. Woodmansee); 9 Sept., 1I (M. Woodmansee).
1968, Santa Paula Canyon: 16 Oct., 1A 1I (L. Fischer).
1968, Hungry Valley: 17 Oct., 4A (D. Beauchamp).
1969, Hopper Canyon: 3 Jan., 4A 1I (JB); 17 Jan., 5A 1I (FS); 23 July, 1A (DC, FS); 22 Oct., 2A (R. Peery, F. Todd).
1969, Bucksnort area: 27 March, 15A 1I (DC); 2 May, 8A (FS); 15 July, 2A (DC, FS).
1969, Agua Blanca: 9 Jan., 6A (JB); 25 March, 3A (DC, JB); 15 Oct., 3A (J. Spruill, C. Rust); 18 Dec., 8A (SW, JB).
1969, Green Cabins, Sespe Creek: 15 Oct., 3A 1I (KA, F. Simas).
1969, Sulfur Mountain (Upper Ojai): 15 Jan., 1A 1I (M. Anderson); 21 Jan., 2A (J. Taft); 4 April, 2A (JB); 16 Aug., 1U (J. Taft).
1969, Simi Valley: 27 Feb., 1A (N. Bean).
1969, Santa Paula Canyon: 14 April, 2A (JB); 20 Nov., 2A (JB); 12 Dec., 2A 1U (JB, SW).
1969, Matilija Creek: 16 April, 1A (DC, FS); 15 Oct., 2U (S. Vehrs).
1969, Reyes Peak: 15 May, 1U (JB); 15 Oct., 1I (W. McGuire, R. Lavender).
1969, Thorn Point: 25 May, 1I (S. Molnar); 29 May, 1A (JB, FS); 11 July, 1A (TZ).
1969, Mt. Pinos: 28 May, 1A (D. Hayden); 13 July, 5U (KA); 24 July, 5A 2I (RMW); 8 Aug., 22A 3I (JB, E. McMillan); 23 Sept., 2A (DC); 15 Oct., 1A 1U (V. and S. Mangold).
1969, Chismahoo — Laguna Ridge: August, 2A (L. Thomas).
1969, Frazier Mountain: 15 Oct., 2A 1I 1U (HU).

1970, Hopper Canyon: 2 Jan., 2A 1U (JB, SW); 30 Jan., 6A (G. Roby); 20 Feb., 6A (JB, SW); 12 Sept., 2A 2I (J. Marquez); 22 Oct., 3A (R. Dalen); 4 Dec., 3A 1I (JB); 23 Dec., 6A 1I (R. Dalen, DCo).

1970, Bucksnort: 27 Jan., 6A 1I (DC, SW); 13 Feb., 5A (JB); 25 May, 4A (JB, DC, SW); 24 Aug., 1A (JB).

1970, Agua Blanca: 3 Sept., 2A (JB).

1970, Moorpark: 17 Jan., 3A (R. May); 28 Jan., 1A (R. May, P. Rains); 3 Feb., 2A (R. May, P. Rains); 2 April, 2A (R. May, P. Rains).

1970, Santa Paula Canyon: 13 Jan., 1A (DC, JB, SW).

1970, Sulfur Mountain: 5 April, 1I (J. Taft).

1970, Thorn Point: 7 April, 1A (JB, SW); 20 June, 1A (R. Albee); 7 Aug., 1A (R. Albee); 17 Sept., 1A (R. Albee).

1970, Reyes Peak: 12 April, 2A 1I (DC); 28 May, 3U (JB, SW).

1970, Mt. Pinos: 14 June, 1A 2I (KA); 4 July, 4A 4U (RMW); 10 Aug., 6U 1I (JB); 11 Aug., 6A (DC); 22 Aug., 4A 2I (SW).

1970, Frazier Mountain: 10 July, 1A (HU); 12 Aug., 1I (HU); 19 Aug., 10A 2I (HU); 21 Oct., 1A (SW, HU).

1971, Hopper Canyon: 26 Nov., 2A (DC); 1 Dec., 4A 2I (SW); 15 Dec., 3A 2I (SW); 17 Dec., 3A 1I (DC).

1971, Bucksnort: 24 Jan., 1A 1I (J. Marquez); 16 Feb., 2A 1I (JB, SW); 26 Feb., 9A (SW, JB); 20 March, 5A 1I 2U (S. and S. Wilbur); 29 April, 1A 2U (SW, S. Rouleau); 14 May, 5A 2I (JB, SW); 4 June, 5A (JB, SW); 3 July, 4A 1I (DC).

1971, Sulfur Mountain: 1 Feb., 2U (J. Taft); 17 Feb., 2A (J. Taft).

1971, Potrero Seco: 1 April, 2U (G. Roby).

1971, Matilija Creek: 6 April, 2U (E. Gregory).

1971, Simi Valley: 2 May, 1U (N. Bean).

1971, Moorpark: 5 May, 1I (SW).

1971, Nordhoff Peak: 15 May, 1A (R. Albee); 19 June, 2A (R. Albee).

1971, Frazier Mountain: 20 June, 1A (HU); 28 July, 2A (HU).

1971, Mt. Pinos: 17 June, 1A (O. Clark); 10 Aug., 1A 1I (JB); 26 Aug., 4A 3U (JB, SW); 15 Sept., 1A (SW).

1971, Reyes Peak: 27 Aug., 1A (JB).

1971, Thorn Point: 12 Sept., 1A (A. Lopez); 15 Nov., 1A (A. Lopez).

1972, Hopper Canyon: 10 Jan., 2A 2I (JB, SW); 3 Feb., 3A 1I (SW); 7 Feb., 4A 2I (DC, F. Todd); 2 March, 5A 1I (SW, JB); 2 April, 4A 2I (DC, SW); 26 May, 6A 2I (JB, SW); 1 June, 5A 1I 3U (SW); 3 Aug., 1A 2I (SW); 21 Sept., 2A (SW); 30 Oct., 1A 1I (SW); 30 Nov., 3A 2I (JB, SW).

1972, Potrero Seco: 25 Jan., 1A (T. Ingersoll).

1972, Santa Paula Canyon: 28 Jan., 3A 2U (D. Campbell, S. Kurcaba).

1972, Matilija Creek: 4 Feb., 1A (DC).

1972, Reyes Peak: 2 May, 1A 1I (D. Schroeder).

1972, Frazier Mountain: 20 Sept., 1A (HU); 15 Oct., 1I (HU).

1972, Mt. Pinos: 18 June, 3A 3U (KA); 15 July, 1A 1I (W. Bremser); 1 Sept., 3A (SW).

1972, Simi Valley: 23 June, 1A 1I (G. Williams); 11 Sept., 2A (D. Hayes).

1973, Hopper Canyon: 20 Jan., 4A (JB); 31 Jan., 6A (SW); 26 Feb., 4A 1I (T. Raley); 4 April, 3A 1I (DC, SW); 2 May, 2A 2I (JB, SW); 3 Oct., 3A (DC, T. Raley); 5 Dec., 5A (JB, SW).

1973, Matilija Creek: 2 Feb., 1A (JB, SW).

1973, Sulfur Mountain: 6 Feb., 2A (J. Taft).

1973, Reyes Peak: 6 April, 1U (SW).

1973, Thorn Point: 10 July, 1A (JB).

1973, Mt. Pinos: 11 July, 2A (SW); 28 July, 1A 2I 2U (KA).

1973, Frazier Mountain: 25 July, 1A (HU).

1974, Hopper Canyon: 23 Jan., 3A (JB, SW); 19 April, 6A 1I (JB); 14 June, 4A (JB); 10 Sept., 1I (D. Moody); 12 Nov., 1A (JB, SW); 27 Dec., 2A (M. Montagne, D. Moody).

1974, Bucksnort: 19 March, 3A (JB, SW).

1974, Sulfur Mountain: 3 March, 1A (J. Taft).

1974, Thorn Point: 31 March, 1A 1I (T. Adams); 28 May, 1A (D. O'Connor); 4 Aug., 1A (D. O'Connor); 10 Oct., 1I (D. O'Connor).

1974, Frazier Mountain: 11 June, 1I (HU); 15 June, 2A (HU); 8 Sept., 3A (HU).

1974, Mt. Pinos: 22 June, 1A (JB); 17 Aug., 2A 1I (JB).

1974, Santa Paula Peak: 26 July, 1U (T. Sarzotti).

1974, Matilija Creek: 16 Aug., 1A (JB).

1974, Nordhoff Peak: 10 Nov., 1U (E. Gregory).

1975, Hopper Canyon area: 21 Jan., 2A (JB); 18 Feb., 2A 1I (B. Whiting); 25 March, 2I (E. Abeyta); 28 April, 1A 2I (MSl); 11 June, 2A (SW); 15 July, 1A (JB).

1975, Lake Piru: 22 Feb., 2A 1I (A. Moreno); 8 March, 7A (A. Moreno); 27 April, 4A 3U (D. Moody, A. Moreno).

1975, Whiteacre Peak: 27 March, 3A 1I (J. Farley); 10 April, 1A (SW); 29 May, 2A (SW); 29 Dec., 1A (SW).

1975, Frazier Mountain: 11 June, 1A (HU); 5 Aug., 3A 1I (HU).

1975, Mt. Pinos: 23 June, 1A (M. Davidson); 23 July, 2A (H. Herbert); 7 Aug., 3A 1I (D. Van Vuren); 16 Aug., 6A (L. Kiff); 7 Sept., 2A (D. Van Vuren).

1975, Thorn Point: 4 July, 1A (J. Black).

1975, Reyes Peak: 8 Aug., 1A (A. Mercado); 3 Sept., 2A 2I (D. Van Vuren).

1975, Sespe Canyon: 25 Sept., 2A (S. Kurcaba).

1976, Hopper Canyon area: 6 Jan., 6A 2I (D. Moody, J. Rangel); 22 Feb., 1A 1I (MSl); 24 Feb., 6A 2I (SW); 26 March, 3A (MSl, SW); 11 June, 1A (MSl); 17 Dec., 3A (SW).

1976, Lake Piru: 7 Jan., 2A (A. Moreno).

1976, Reyes Creek: 24 Jan., 1A (T. Glenn).

1976, Simi Hills: 22 Feb., 1A (B. Margolis).

1976, Matilija Canyon: 23 Feb., 1U (R. Nelson); 1 April, 1A (R. Nelson); 21 Sept., 1A (D. Pacheco).

1976, Whiteacre Peak: 24 March, 4A 1I (MSl, SW); 5 Oct., 2A (JB, SW); 13 Oct., 3A 1I (MSl); 21 Dec., 3A 1I (SW).

1976, Thorn Point: 25 May, 1A (JB, SW); 12 June, 1A (J. Black).

1976, Reyes Peak: 31 May, 1U (S. Kinchloe); 16 July, 1A (JB).

1976, Frazier Mountain: 3 June, 1I (HU)

1976, Mt. Pinos: 19 June, 1A (F. Maupin); 12 Aug., 1A (D. Waite); 29 Aug., 5U 1I (Santa Monica Bay Audubon Society).

Los Angeles County

1967, Piru Creek Gorge: 5 Jan., 1A (FS); 14 April, 2A 1I (FS); 18 May, 2A (FS); 3 Aug., 1I (FS); 12 Oct., 1A 1I (JB, FS).
1967, Gorman: 24 Oct., 1A (JB).
1968, Calabasas: 3 Jan., 1A 1I (R. Woolford).
1968, Piru Gorge: 20 Feb., 1A 1I (JB).
1968, Whitaker Peak: 12 April, 5A (JB).
1968, Agoura: 15 May, 5A, 1I (D. Bafford).
1969, Calabasas: 19 June, 2A (B. McIntosh).
1969, Piru Gorge: 29 Jan., 1U (G. Roby).
1969, Warm Springs Lookout: 18 July, 1I (M. Stahl).
1969, Slide Mountain: 6 Aug., 1A (GC); 5 Sept., 1A (GC); 15 Oct., 2A (GC).
1969, Gorman: 21 Sept., 1A (J. Mills).
1970, Canton Canyon: 26 Jan., 2A (S. Morgan).
1970, Slide Mountain: 26 Feb., 1A (D. Roberts); 31 May, 2A (GC); 22 Aug., 1I (GC); 15 Sept., 4A (GC); 19 Nov., 2A (GC).
1970, Liebre Mountain: 19 April, 3A 2I (J. Damann).
1971, Slide Mountain: 25 Jan., 1A (JB, R. Bishop); 17 March, 1A 1I (M. Faaborg); 5 May, 2A (GC); 28 July, 1I (GC); 25 Oct., 1A (GC); 29 Nov., 3A (GC).
1971, Whitaker Peak area: 21 Aug., 1U (I. McMillan).
1971, Gorman: 3 Nov., 6A (HC).
1972, Slide Mountain: 24 Sept., 1A 1U (L. Forbis); 11 Oct., 1A (L. Forbis).
1972, Quail Lake: 27 Sept., 1A (DC, JB, SW).
1972, Hungry Valley: 17 Sept., 1I (P. Greene).
1973, Slide Mountain: 16 Feb., 1A (JB).
1973, Quail Lake: 30 May, 1A (WF).
1974, Warm Springs Lookout: 11 June, 2I (M. Stahl).
1975, Slide Mountain: 25 May, 1A (DO); 6 June, 4A (DO); 6 July, 2A 1U (DO); 5 Sept., 2A (DO); 15 Oct., 1A (DO); 25 Nov., 2A 1I (JB).
1975, Calabasas area: 20 Aug., 1A (J. Dunn); 6 Dec., 1A (L. Slate).
1975, Red Rock Mountain: 24 Dec., 2A 1I (S. Hoddy).
1976, Slide Mountain: 5 Jan., 1A (DO); 9 Jan., 1I (DO); 22 June, 1A (D. Mark); 24 Sept., 1A (D. Mark).
1976, Gorman: 27 Feb., 1A (A. Jensen).
1976, Liebre Mountain: 1 April, 3A 2I (SW).
1976, Red Rock Mountain: 29 June, 1I (S. Hoddy).
1976, Quail Lake: 5 Dec., 2A (KA).

Kern County

1966, Bear Mountain: 17 May, 1A (J. Mensch).
1966, Grocer Grade: 8 June, 2A (R. Patterson).
1966, Woody — Granite Station: 26 June, 1A (KA); 27 June, 1I (KA); 5 July, 9A 2I (NW).
1966, Tollgate Lookout: 7 July, 1I (PR); 11 July, 1I (PR); 19 Oct., 1I (PR).

1966, Apache Saddle: 26 July, 2A (T. Ingersoll); 28 July, 1A (R. Fischer); 19 Oct., 1A 1I (J. Lane).
1966, San Emigdio Ranch: 2 Sept., 9A (B. Easley).
1966, Mt. Abel: 4-5 Sept., 2A (J. Mills).
1966, Glennville: 12-18 Sept., 1-2 daily (EF).
1966, Tejon Ranch: 24 Sept., 1I (WF); 13 Oct., 2A (WF); 14 Oct., 3A 2I (WF); 19 Oct., 11A 1I (D. Fry, R. Reed); 9 Nov., 11A (E. McMillan).
1967, Tejon Ranch: 18 Jan., 10A (FS, JB); 1 March, 2A (WF); 21 June, 1I (J. Bailey); 29 Aug., 1A 1I 1U (C. Graves); 4 Nov., 5A (WF); 24 Oct., 16A 3I (FS); 30 Dec., 1A (WF, E. Cofer).
1967, Granite Station: 25 Jan., 1A (NW); 9 April, 2A 1I (NW).
1967, Tehachapi: 28 May, 2A (F. Harris).
1967, Bear Mountain: 2 June, 2A (FS); 3 Aug., 8A 2I (L. Bouscal).
1967, Mt. Abel: 19 July, 2A (DS); 24 Nov., 1A (R. Fischer).
1967, Glennville: 11 July, 2A 1I 4U (EF); 26 Aug., 3A (EF); 6 Sept., 2A 2I (EF); 22 Sept., 2I (EF).
1967, Breckenridge Mountain: 6 Sept., 2A (FS).
1967, Tecuya Ridge: 17 Sept., 1I (C. Graves).
1967, Tollgate Lookout: 24 Oct., 1A (PR).
1967, Oak Flat Lookout, Sequoia Natl. Forest: 18 Oct., 2I (J. Koroloff).
1967, San Emigdio Ranch: 18 Oct., 1A 1I (J. Lane, R. Feldman).
1968, Bear Mountain: 8 Jan., 10A 4U (L. Bouscal); 23 Feb., 3A 1I (FS, RM); 8 May, 1A 1U (E. Cofer, G. Franklin); 16 Oct., 1I (RP).
1968, Tejon Ranch: 7 Feb., 2A (E. Cofer, WF); 8 Aug., 1U (DC, FS); 3 Sept., 9A 1I (HC); late Oct., 25U (WF); 17 Oct., 8A (C. Graves, R. Fordice); 24 Oct., 23A 3I (RM, R. Buss).
1968, Kelso Valley: 14 March, 1A (RP).
1968, Caliente: 15 March, 8U (L. Barrett); 28 Oct., 2A (G. Beerline).
1968, Granite Station: 16 April, 2A (NW).
1968, Kern Canyon near Ming Lake: 18 April, 4A (E. Schneegas).
1968, Yeaguas Mountain: 19 June, 1I (J. Edwards).
1968, Glennville: 26 June, 2A (EF); 21 July, 1A (SS); 11 Aug., 1A (EF); 24 Aug., 13A (EF).
1968, Mt. Abel: 13 Aug., 3A 3I (J. Hunter).
1968, Tecuya Ridge: 27 Aug., 1A 1I (D. Roberts).
1968, San Emigdio Ranch: 16 Oct., 5A (J. Lane, D. Partridge).
1969, Glennville: 1 Feb., 1U (R. Shackelford); 24 Aug., 5A (EF); 15 Sept., 2A (EF).
1969, Garces Highway near Highway 65: 12 Feb., 1I (SS).
1969, Mt. Abel: 16 Feb., 1A 1I (D. Taylor).
1969, Tejon Ranch: 3 March, 1U (HC); May, 2A (WF); 15 Oct., 15U (H. Hagen, D. Zeiner); 22 Oct., 6A (RM, J. Reed); 29 Oct., 12U (WF).
1969, Tehachapi: April, 1A (F. Harris).
1969, Bear Mountain: 6 May, 2A (L. Bouscal); 15 Oct., 2A (RP, B. Easley).
1969, Granite Station: 14 June, 1A (NW); 6 Sept., 2A (NW); 11 Sept., 1I (NW).
1969, Tollgate Lookout: 7 Sept., 2A (PR); 15 Oct., 1I 1U (PR).
1969, Santiago Canyon: 2 Aug., 1A (HC, R. Fischer); 15 Oct., 1A (D. Partridge, J. Lane).

1970, Breckenridge Mountain: 8 April, 1A (C. Graves, W. Asserson); 23 May, 1U (G. Payne); 22 Sept., 1A (W. Asserson, R. Thomas).
1970, Granite Station: 1 May, 3A (C. Graves, W. Asserson); 6 Sept., 2A (NW).
1970, Bear Mountain: 8 June, 7A 5I (RP).
1970, Glennville: 24 July, 8A 3I (EF); 4 Aug., 8A 2I (EF); 15 Aug., 4A 2I (EF); 21 Aug., 5A 17U (EF); 3 Sept., 15U (EF); 4 Sept., 3I 10U (EF); 14 Sept., 13U (EF).
1970, Tollgate Lookout: 17 Aug., 1I (PR); 10 Nov., 1A (PR).
1970, Tejon Ranch: 27 Sept., 5A (WF); 12 Oct., 8A (JB); 29 Oct., 9A (D. Beauchamp, C. Graves); 12 Nov., 13A 1I 5U (SW, RM); 29 Dec., 11U (WF).
1970, Woody: 18 Sept., 7A 2I (SS).
1970, San Emigdio Ranch: 21 Oct., 1U (R. Thomas, D. Partridge).
1970, McKittrick Summit: 4 Nov., 1A (K. Jones).
1971, Caliente: 8 Jan., 1A (R. Buss).
1971, Tejon Ranch: 9 Jan., 8A 1I 7U (HC); 27 Jan., 10A 1I (HC); 24 Feb., 4A (SW, RM); 29 Sept., 5A 1I 2U (JB); 7 Oct., 17A 1I (SW); 14 Oct., 8A 6U (R. Beauchamp, R. Fordice); 6 Nov., 7A (D. Kirks).
1971, McKittrick Summit: 13 June, 1A (F. Todd, N. Gale).
1971, Granite Station: 14 March, 2I (Mrs. F. Stockton).
1971, near Arvin: 27 April, 1A 1I (G. King).
1971, Tollgate Lookout: 9 July, 1I (PR); 29 July, 2A (PR); 11 Sept., 1I (IS).
1971, Glennville: 21 Aug., 4A 1I (EF); 31 Aug., 6A 1I (SW); 9 Sept., 12U (EF).
1972, Granite Station: 23 Jan., 1A (EF); 23 June, 2I (NW); 19 Aug., 4A (M. Carver); 30 Sept., 3A 1I (NW).
1972, Blue Mountain: 15 June, 3A (IS); 29 June, 3A 1I (IS); 1 Aug., 1A 2I (IS); 15 Aug., 3A 12U (IS); 18 Sept., 2A 3U (IS).
1972, Glennville: 29 Aug., 9A 1I (SW); 30 Aug., 6A 6U (EF); 2 Sept., 24U (EF).
1972, Tejon Ranch: 31 Aug., 2A 2I (SW); 17 Sept., 1A 1I (R. Reed).; 4 Oct., 5A 1I 1U (JB, SW); 11 Oct., 18A (KA, J. Tarble, K. Stager).
1973, Granite Station: 28 Jan., 1I (M. Carver); 6 Sept., 5A 1I 8U (M. Carver).
1973, Tejon Ranch: 5 March, 2I (WF); 23 March, 7U (WF); 6 Aug., 4A (WF); 7 Oct., 5A 1I 1U (SW, R. Erickson); 25 Oct., 12A 1I (JB, E. McMillan).
1973, Bear Mountain: 4 April, 1I (J. Daum); 19 April, 4A 1I (W. Long, J. Daum); 2 July, 1I (L. Stevens), 13 Oct., 10U (WF).
1973, Glennville: 13 Aug., 4A (E. McMillan); 22 Aug., 7U (EF); 28 Aug., 1I 9U (EF).
1973, Santiago Canyon: 22 Aug., 3A (RP).
1974, Temblor Valley: 20 April, 2A (C. Twisselman).
1974, Glennville: 22 April, 1A (EF).
1974, McKittrick Summit: 8 May, 1A (D. Clark).
1974, Breckenridge Mountain: 25 July, 1U (R. Nelson); 7 Nov., 1I (J. Shryer).
1974, Tejon Ranch: 9 Sept., 5A 1I (WF); 3 Oct., 11A 1I (D. Hartman); 16 Oct., 7A 1I (SW, M. Brayton); 17 Oct., 12 A (L. Kiff, E. Harrison); 14 Nov., 5A 1I 1U (SW, JB).
1974, Granite Station: 23 Sept., 1A (M. Carver).

1974, Cummings Mountain: 29 Sept., 7A 2I (C. Swick).
1974, Santiago Canyon: 17 Oct., 3A (R. Fordice, R. Buss).
1975, Glennville: Aug., 6A 2I (EF).
1975, Granite Station: 9 Sept., 3A 2I (N. Williams).
1975, Tehachapi Pass: 19 Sept., 1A 1U (J. Chattin).
1975, Tejon Ranch: 27 Sept., 6A 2I (JB); 3 Dec., 2A (SW).
1976, Granite Station: 3 Jan., 1I (F. Stockton); 22 June, 1A 2I (F. Stockton).
1976, Tecuya Ridge: 2 June, 2A 1I (R. Long).
1976, Tejon Ranch: 18 June, 2U (H. Einspahr); 26 Sept., 3A (KA); 10 Oct., 4A 3U (KA); 14 Oct., 7A 3I (L. Kiff).
1976, Glennville: 21 June, 4A 4I (G. Record); 7 Aug., 1A 1I (EF).

Tulare County

1966, Mule Peak: 15 June, 2A 1I (M. Barkley); 17 June, 1I (M. Barkley).
1966, Cahoon Rock: 20 May, 1U (L. Kilgore, C. Castro).
1966, Blue Ridge: 30 May-23 Aug., almost daily observations, 1-8 birds, including 1-2I (CO); 5 Sept., 1A (CO); 17 Sept., 1U (CO).
1966, Tobias Lookout: 10 Oct., 2A 1I (I. Stephenson); 25 Oct., 2U (I. Stephenson).
1966, Milk Ranch Lookout: 19 Oct., 1U (M. Sitton).
1967, White River: 3 Feb., 1U (FS); 22 Dec., 2U (EF).
1967, Blue Ridge: 30 June, 1A 2I (CO); 21 June, 2A (CO); 1 July, 1I 1U (CO); 14 July, 1A (CO); 28 July, 1A 1U (CO); 7 Aug., 2A 1I (CO); 8 Sept., 1A (CO).
1967, Milk Ranch Lookout: 12 Aug., 1A (A. Peterson).
1968, White River: 5 Feb., 1A (SS); 13 Feb., 1A 2U (SS); 11 March, 3U (SS); 31 May, 1I (SS).
1968, Springville: 1 March, 1U (M. Mires); 25 Aug., 1A (L. Bastian).
1968, Yokohl Valley: 24 March, 2U (M. Mires).
1968, Jordan Peak: 31 May, 2A (W. Beeler).
1968, Blue Ridge: 10 June, 1A (CO); 14 June, 2A (CO); 25 Aug., 2A 1I (CO); 8 Sept., 1A (CO).
1968, Coldsprings Peak: 11-12 and 17-18 June, 1A each day (FS).
1968, Mule Peak: 7 July, 1A (M. Barkley); 25 Aug., 1A (M. Barkley); 3 Oct., 2A (M. Barkley); 17 Oct., 1A (M. Barkley).
1968, Shadequarter Mountain: 16 Aug., 1A (L. Bawden).
1968, Colony Mill Road, Sequoia Natl. Park: 3 Oct., 1I (C. Shaver).
1968, Tobias Peak: 4 Oct., 2A (I. Stephenson); 21 Oct., 1A (I. Stephenson).
1969, Lake Success: 9 March, 2U (M. Mires).
1969, Blue Ridge: 20 May, 1A (FS, DC); 3 June, 2A (CO); 21 June, 5U (MS); 23 June, 1A 3I (CO); 5 July, 8U (MS); 9 July, 11U (CO); 24 July, 2A 1I (CO); 9 Aug., 7U (MS); 29 Aug., 2A 2I (MS); 12 Sept., 1A (MS).
1969, Coldsprings Peak: 25 Sept., 1I (N. Rickert).
1969, near Orange Cove: 29 Sept., 1A (R. Bigard).
1970, California Hot Springs: 7 April, 2I (B. Waldron, N. McDougald).
1970, Blue Ridge: 28 May, 2I (CO); 5 June, 2A 1I (MS); 22 June, 4A (CO, DC, SW); 3 July, 3A (MS); 7 July, 4A 1I (CO); 27 July, 1A 1I (MS); 10 Sept., 1I (CO).

1970, Mule Peak: 27 May, 2A (E. Schneegas).
1970, White River: 14 June, 1A (SS).
1970, Yokohl Valley: 20 Aug., 2U (S. Stout).
1970, Success Lake: 11 Sept., 1A (L. Bastian).
1970, Milo: 24 Dec., 1A (F. Lilland).
1971, Mule Peak: 15 June, 1A (M. Barkley).
1971, Blue Ridge: 22 June, 1A 1I (SW, CO); 2 July, 1A 1I (CO); 31 July, 2A (MS); 16 Aug., 5A 3U (MS); 27 Aug., 3A 2I (MS); 22 Sept., 2A 1I (CO); 10 Oct., 2A (MS).
1971, Frazier Valley: 11 Sept., 5A (L. Bastian); 15 Sept., 9A 2I (L. Bastian); 22 Sept., 4A 2I (SW).
1971, Park Ridge Lookout, King Canyon Natl. Park: 22 Sept., 2I (M. Sims).
1971, Buck Canyon, Sequoia Natl. Park: 29 Sept., 1I (G. O'Connell).
1972, White River: 30 Jan., 5U (SS); 20 April, 2A (L. Bastian).
1972, Yokohl Valley: 17 March, 2U (H. Ruth).
1972, Mule Peak: 16 May, 2A (M. Barkley).
1972, Blue Ridge: 14 June, 2A 1I (MS); 27 June, 2A 1I (MS); 21 July, 1A 2I (MS).
1973, Springville: 21 May, 1A (J. Probasco, R. Sheldon).
1973, Blue Ridge: 26 June, 3A 2I (MS); 29 July, 3A 3U (MS).
1973, Coldsprings Peak: 15 July, 1I (R. Day).
1973, Needles Lookout: 19 Aug., 1A (A. Fritz).
1974, Springville: 12 May, 3U (H. Miller); 21 Aug., 3A (V. Chapman).
1974, Blue Ridge: 6 June, 2A (MS); 17 Aug., 3A (MS).
1975, Blue Ridge: 5 June, 2A (MS); 11 July, 4A (MS); 14 July, 1I (F. Torreano).
1975, Yokohl Valley: 21 May, 2U (G. Cunningham).
1976, Blue Ridge: 16 June, 2I (F. Torreano); 13 July, 1A (F. Torreano); 15 July, 1I (F. Torreano); 17 Sept., 2A (C. Layton).
1976, Fountain Springs: 4 Dec., 1A (SS); 17 Dec., 1I (SS).

Fresno County

1968, Trimmer: 5 Feb., 2A (V. Murray).
1969, Huntington Lake: August, 1A (W. Cook).
1971, Balch Camp: 25 Feb., 1A 1I (R. Kramer).

San Bernardino County

1967, Deep Creek, San Bernardino Natl. Forest: 22 Aug., 1A (J. Light).

Riverside County

1969, Joshua Tree Natl. Monument: 31 March, 1A (P. Hessler).

APPENDIX II

Removals from the California Condor Population

Museum records and published reports give some indications of the timing and magnitude of losses within the California condor population. The following tables record these losses; however, they do not give a true picture of the actual effects of various mortality factors. For example, only a few Indian-collected birds are listed. Also, many condors were probably shot or otherwise disposed of over the years and no written records exist. Although I have tried to limit the "museum related collecting" to those specimens purposefully acquired by or for museums and other collectors, some birds lost to other causes probably are included. Therefore, the toll of "collecting" is probably overstated, and that of other factors understated.

In the egg records, I have made no attempt to differentiate between the impact of oologists (those with real interest in keeping, cataloging, and studying eggs) and those who collected eggs to sell. Although one might argue that motives make a difference, it seems to me that the second group would not have existed had there not been demand from the first.

As many as 13 museum specimens with incomplete data may duplicate published records for which no existing specimens have been found. Therefore, a minimum of 288 condors and 71 eggs are known removed from the population between 1792 and 1976.

Abbreviations for age are: A, adult; I, immature; and U, unknown. Abbreviations for cause are: S, shooting; MC, museum related collecting; OC, other purposeful capture; AC, accidental trapping; AS, accident or sickness; P, poisoned; and U, unknown.

All specimen locations are in California unless otherwise noted. Abbreviations used in "Reference" are: *NHM*, natural history museum; *NS*, no specimen saved; *SLU*, specimen location unknown; *AMNH*, American Museum of Natural History; *ANSP*, Academy of Natural Sciences, Philadelphia; *BM*, British Museum; *CAS*, California Academy of Sciences; *CFM*, Chicago Field Museum of Natural History; *HMCZ*, Harvard Museum of Comparative Zoology; *LACM*, Los Angeles County Museum; *MVZ*, Museum of Vertebrate Zoology, University of California; *UCLA*, University of California at Los Angeles; *USNM*, U.S. National Museum; *WFVZ*, Western Foundation of Vertebrate Zoology.

Table A-1. *Documented Losses of California Condors, 1792-1976.*

Date	Location	Age	Sex	Cause	Reference
December 1792	Monterey County	A	U	MC	BM — Type specimen
18 November 1805	Pacific County, Washington	U	U	MC	NS — Lewis and Clark Journals
16 February 1806	Clatsop County, Oregon	A	U	MC	NS — Lewis and Clark Journals
15 March 1806	Clatsop County, Oregon	U	U	S	NS — Gass 1904
15 March 1806	Clatsop County, Oregon	U	U	S	NS — Gass 1904
6 April 1806	Multnomah County, Oregon	U	U	S	NS — Lewis and Clark Journals
September ? 1825	Clark County, Washington	U	U	MC	SLU — Scouler 1905
March 1826	Clark County, Washington	U	U	MC	NS — Douglas 1914
October 1826	Lane County, Oregon	U	U	MC	NS? — Douglas 1914
February 1827	Clark County, Washington	A	U	MC	SLU — Douglas 1829, 1914
1827?	Clark County, Washington	A	U	MC	SLU — Douglas 1829
April 1835	Clackamas County, Oregon	I	U	MC	Townsend 1848, USNM 78005
November? 1836	Monterey County	A	F	MC	Berlin Museum
1840's	Sonoma County	U	U	OC	Leningrad Museum
1840's	Sonoma County	U	U	OC	Leningrad Museum
1841?	Sonoma County?	I	U	MC	Leningrad NHM 1584
1841	Sonoma County?	A	F	MC	Leningrad NHM 1583
1845?	California	A	U	MC	ANSP 148146
1845?	California	A	U	MC	ANSP 148147
8 September 1845	Napa County	U	U	S	NS — Clyman 1926
19 September 1849	Colusa County	A	U	S	NS — Stillman 1967
20 October 1849	Tehama County?	U	U	S	NS — Reed & Gaines 1949
1851?	Lane County, Oregon	U	U	S	NS — Putnam 1928
1853?	Monterey County	A	M	MC	BM
1853?	Monterey County	A	M	MC	BM 1955.6.N.20.135
1855?	California	U	U	MC	CAS — specimen destroyed
26 July 1855	Monterey County	I	F	MC	BM 1955.6.N.20.136
April 1859	Monterey County	I	U	MC	BM

Early 1860's?	Monterey County	U	U	OC	BM 1868.12.29.17
1866	Monterey County	I	M	MC	CFM 95160
1867	Monterey County	I	U	MC	Vienna NHM 40862
1872 or 1873	California	I	U	MC	CAS — specimen destroyed
17 June 1875	San Diego County	A	M	MC	CAS skin, MVZ skeleton 23338
1 January 1877	Monterey County	I	M	MC	CAS
2 November 1878	Los Angeles County	U	U	S	NS — Reid 1895
1878?	Tulare County	U	U	S	NS — C. Osborn, pers. comm.
27 January 1880	San Luis Obispo County	A	M	MC	MVZ 23333
May 1880	San Diego County	U	U	S	NS — Cleveland 1902
1882?	Tehama County	U	U	S	NS — Townsend 1887
10 October 1884	Monterey County	A	M	MC	HMCZ 80168
May 1884	Santa Barbara County	U	U	OC	NS? — Reported in *Ventura News* May 23, 1884
February? 1885	Monterey County	I	U	MC	USNM 103375
February 1885	Monterey County	I	U	MC	USNM 17050
February 1885	Monterey County	A	U	MC	USNM 17047
February 1885	Monterey County	I	U	MC	USNM 103065
February 1885	Monterey County	I	U	MC	Skin BM 1888.10.16.156, Skeleton USNM 17049
13 June 1886	Santa Barbara County	A	M	MC	MVZ 23336
2 August 1886	Riverside County	I	U	MC	HMCZ
1887	Baja California	U	U	S	NS — Grinnell 1928
1887	Baja California	U	U	S	NS — Grinnell 1928
1887	Baja California	U	U	S	NS — Grinnell 1928
3 January 1888	San Diego County	A	M	MC	CAS 19001
16 February 1888	San Luis Obispo County	A	M	MC	MVZ 23335
12 March 1888	San Diego County	I	F	MC	HMCZ 214367
11 May 1888	San Diego County	A	M	MC	HMCZ 80166
2 June 1888	San Diego County	A	F	MC	LACM
1888	California	A	U	MC	Milwaukee NHM 457
1888	Monterey County?	A	U	MC	USNM 113663

Table A-1.(Con't.) *Documented Losses of California Condors, 1792-1976.*

Date	Location	Age	Sex	Cause	Reference
10 January 1889	Monterey County	A	M	MC	CFM 130025
July 1889	Santa Barbara County	A	M	MC	AMNH 469948
8 August 1889	San Benito County	A	U	MC	University of Arizona 3993
1889 or 1890	Humboldt County	I	U	MC	Clarke Museum, Eureka, California
1889	Los Angeles County	U	U	OC	SLU — Lawrence 1893
1890	Fresno County	U	U	P	NS — Fry 1926
1890	Fresno County	U	U	P	NS — Fry 1926
1890	Ventura County	A	U	MC	LACM 18877
10 May 1890	Monterey County	U	U	MC	SLU — Davie 1898
13 August 1890	San Diego County	A	M	MC	San Diego NHM
9 December 1890	San Diego County	A	M	MC	AMNH 469945
10 September 1891	San Diego County	A	M	MC	Peabody Museum (Yale) 8526
1892	Humboldt County	A	U	OC	Clarke Museum, Eureka, California
June 1892?	Los Angeles County	A	U	AS	CFM? Lawrence 1893?
1 June 1892	San Luis Obispo County	A	M	MC	BM 1915.7.12.1
8 January 1893	Riverside County	A	U	MC	CAS
1893?	Unknown	U	U	MC	CAS, destroyed by fire
March? 1893	Santa Barbara County	U	U	S	SLU, *Santa Barbara News*, April 12, 1968
20 July 1893	San Diego County	A	F	MC	CAS 44495
August 1893	San Diego County	A	U	MC	USNM 135475
1 January 1894	San Diego County	A	M	MC	CAS 19002
August 1894	Santa Cruz County	U	U	S	NS? Taylor 1895
10 September 1894	San Diego County	A	F	MC	AMNH 469946
25 December 1894	California	A	M	MC	Swedish NHM 16673
20 February 1895	Santa Barbara County	A	M	MC	MVZ 23334
21 April 1895	Los Angeles County	A	M	MC	SLU, Hoffman 1895
23 October 1895	San Diego County	I	M	MC	AMNH 469944
1896?	Santa Barbara County	U	M	U	UCLA 201, partial skeleton

3 February 1896	Monterey County	A	M	MC	AMNH 469943
1896?	Monterey County	A	U	MC	Santa Barbara NHM
April 1896	Monterey County	I	U	OC	ANSP 36094
April 1896	Monterey County	I	U	OC	ANSP 62138
1 May 1896	Ventura County	A	F	MC	Royal Ontario Museum 35618
25 June 1896	San Benito County	A	U	MC	Hastings (Nebraska) Museum 3633
7 July 1896	Monterey County	I	U	OC	SLU, Holmes 1897
8 September 1896	San Diego County	A	M	MC	AMNH 469947
15 October 1896	Santa Barbara County	A	F	MC	AMNH 469949
April 1897	Monterey County	A	M	MC	Vienna NHM 50818
10 April 1897	California	I	U	MC	Ohio State University 5623
16 April 1897	Ventura County	I	F	MC	AMNH 469941
1 May 1897	San Luis Obispo County	I	M	MC	Royal Ontario Museum 35617
6 June 1897	San Luis Obispo County	A	M	MC	BM 1939.12.9.3411
8 October 1897	Orange County	I	U	MC	AMNH 469940
20 February 1898	Santa Barbara County	A	U	MC	CAS
March 1898	Monterey County	I	U	MC	HMCZ 80167
March 1898	Monterey County	A	U	MC	USNM 168797
March 1898	Monterey County	I	U	MC	USNM 168798
5 March 1898	Los Angeles County	I	U	AS	LACM 5860
2 May 1898	Santa Barbara County	A	F	MC	Leningrad NHM 133315
May 1898	Monterey County	I	U	MC	USNM 168799
May 1898	Monterey County	I	U	MC	USNM 168800
8 June 1898	Monterey County	A	M	MC	HMCZ 246480
June 1898	Monterey County	I	U	MC	USNM 168801
1898	Kern County	U	U	S	NS, Koford 1953:145
16 June 1898	Monterey County	I	M	MC	HMCZ 80170
25 August 1898	Los Angeles County	A	U	MC	SLU, Rising 1899
25 August 1898	Los Angeles County	I	U	OC	SLU, Rising 1899
November 1898	Monterey County	I	U	MC	Ottawa, National NHM
8 November 1898	Monterey County	I	M	MC	Delaware NHM 5164
1899	San Diego County	U	U	OC	SLU, feather skirt, Koford 1953

Table A-1.(Con't.) *Documented Losses of California Condors, 1792-1976.*

Date	Location	Age	Sex	Cause	Reference
April 1899	California	A	U	MC	Vienna NHM 64841
1899	California	I	M	MC	St. Gallen (Switzerland) NHM
10 May 1899	San Diego County	A	F	MC	SLU, Finley 1908
24 May 1899	San Diego County	A	M	AS	NS? Stephens 1899
July 1899	California	A	M	MC	St. Gallen (Switzerland) NHM
11 August 1899	Santa Barbara County	A	F	MC	University of Illinois (Urbana) Z-1619
11 August 1899	Santa Barbara County	A	M	MC	University of Illinois Z-522
27 November 1899	Santa Clara County	A	M	MC	AMNH 469942
1900	Ventura County	I	U	OC	USNM 201427
Early 1900's	Tulare County	U	U	S	NS, Stewart 1908
Early 1900's	Tulare County	U	U	S	NS, Stewart 1908
20 April 1900	Santa Barbara County	I	M	MC	HMCZ 324
July 1900	San Diego County	A	U	MC	BM 1939.12.9.3414
10 August 1900	California	A	F	MC	CFM 11249
10 August 1900	California	A	M	MC	Milwaukee Museum 324
15 August 1900	California	A	M	MC	CFM 11248
15 August 1900	California	I	F	MC	Milwaukee Museum 12146
Early 1900's	Marin County	A	U	MC	CFM 39613
1901	San Diego County	I	U	S	SLU, Sharp 1918
1901	Monterey County	I	U	OC	USNM 192532
1901	Ventura County	I	M	OC	USNM 389300
16 January 1901	Los Angeles County	I	F	S	LACM 5829
February 1901	California	A	M	MC	University of Michigan 215,051
3 April 1901	California	A	M	MC	HMCZ 324
1902	Santa Barbara County	A	U	MC	Santa Barbara Museum, destroyed
May 1902	Santa Barbara County	I	F	OC	USNM 188797
December 1902	Santa Barbara County	I	U	MC	AMNH 352007
December 1902	San Luis Obispo County	A	F	MC	AMNH 90572
1903	Ventura County	A	U	MC	University of Michigan

1903	Ventura County	I	F	OC	USNM 370997
1903	Ventura County	I	F	OC	Louisiana State University
1903	San Diego County	A	U	MC	San Diego NHM
March 1903	Santa Barbara County	A	M	MC	CAS 25775
March 1903	Santa Barbara County	A	F	MC	CAS 25776
1903	Santa Barbara County	I	M	OC	HMCZ 300353
1904	Los Angeles County	U	U	S	UCLA 1562 (skeleton)
1904?	Los Angeles County	A	U	S	UCLA
20 April 1905	San Bernardino County	A	M	MC	Denver Museum
May 1905?	Monterey County	A	F	MC	AMNH 750092
22 July 1905	Baja California	I	U	MC	USNM 203218
26 July 1905	Baja California	A	F	MC	USNM 203219
26 July 1905	Baja California	I	U	MC	USNM 203217
1906?	Los Angeles County	I	U	MC	Pomona College
17 June 1906	Ventura County	I	F	MC	AMNH 750093
20 January 1907	California	A	M	MC	Linz, Austria, NHM
1 December 1907	Baja California	A	F	MC	Virginia Polytechnic Institute
1907?	Baja California	A	M	MC	WFVZ
7 February 1908	Ventura County	A	F	MC	AMNH 750094
September 1908	Orange County	U	U	U	NS, H. Swarth field notes
31 December 1908	Los Angeles County	I	M	S	MVZ 7857
1909	Ventura County	I	U	OC	SLU, New York Zoo records
1910	California	I	U	OC	University of Iowa NHM
1911	Kern County	U	U	U	UCLA 318 (skeleton)
8 April 1911	Ventura County	I	F	MC	HMCZ 180862
8 April 1911	Ventura County	A	M	MC	UCLA 11036
June 1911	Los Angeles County	I	M	MC	LACM 20962
1912?	Unknown	I	U	MC	MVZ 23337
1912	Ventura County	I	F	S	UCLA 386
1913?	San Luis Obispo County	U	U	U	NS, Koford 1953:142
April 1916	Ventura County	A	F	MC	LACM 1879, Bi 139
2 April 1916	Ventura County	A	M	S	LACM 20963

Table A-1.(Con't.) *Documented Losses of California Condors, 1792-1976.*

Date	Location	Age	Sex	Cause	Reference
2 April 1916	Ventura County	A	M	MC	AMNH 352005
5 May 1917	Ventura County	I	U	MC	CAS
11 May 1917	Ventura County	A	M	MC	CAS; skeleton UCLA 588
17 May 1917	Ventura County	A	F	MC	CAS; skeleton UCLA 511
June 1917	Monterey County	I	F	OC	CAS 19010
30 May 1920	Ventura County	I	U	MC	LACM 4795, skeleton UCLA 532
30 May 1920	Ventura County	A	M	MC	LACM (4793?)
30 May 1920	Ventura County	A	M	MC	LACM (4794?)
23 October 1923	Ventura County	I	F	OC	LACM 15885
23 October 1923	Ventura County	A	F	MC	LACM 4896
1924?	Santa Barbara County	I	U	AS	NS, Forest Service records
1924	Ventura County	A	F	MC	Denver Museum 19620
1924	Ventura County	A	U	MC	Denver Museum 19621
1924	Ventura County	A	U	MC	Denver Museum
1924	Ventura County	A	M	MC	Denver Museum 19619
1925?	California	A	U	S	San Diego NHM
August 1927	Santa Barbara County	A	U	S	Santa Barbara NHM
July 1929?	Ventura County	I	F	AS	San Diego NHM 18117
1932?	Kern County	U	U	AS	NS, Koford 1953:145
1932	Baja California	U	U	S	NS, Scott 1936a
1932	Baja California	U	U	S	NS, Scott 1936a
1933	Baja California	U	U	S	NS, Scott 1936a
1934?	Ventura County	I	U	AS	Pioneer Museum, Ventura
17 October 1936	Santa Barbara County	A	F	AS	Santa Barbara NHM
17 October 1936	Santa Barbara County	I	M	AS	Santa Barbara NHM, destroyed
December 1936	Ventura County	A	U	U	Santa Barbara NHM
1937?	Kern County	U	U	AT	NS, Howard 1938
1 January 1937	Kern County	A	U	AS	NS, Miller & Fisher 1938
8 October 1938	Santa Barbara County	U	U	U	MVZ 74888 (skeleton)

1939	Ventura County	U	U	U	NS, Koford 1953:129, 143
2 February 1941	Ventura County	I	U	AS	MVZ 131373
June 1941	Kern County	A	F	U	Fresno State College
1941	Ventura County	I	U	AS	MVZ 120358
1943	Los Angeles County	U	U	S	NS, Department of Fish & Game files
24 August 1944	Kern County	A	U	S	Foster Bighorn Bar, Rio Vista, California; Koford 1953:146
1945	Kern County	A	U	AS	Santa Barbara NHM (skeleton)
20 October 1945	Ventura County	I	U	AS	MVZ 115625
3 March 1946	Ventura County	U	U	U	MVZ 120359
1946	San Luis Obispo County	U	U	U	NS, Miller et al. 1965:55
12 March 1948	Kern County	I	M	AT	LACM Bi 1800
1948	Kern County	U	U	S	NS, Miller et al. 1965:58
1950	San Luis Obispo County	U	U	U	NS, F. C. Sibley notes
28 February 1950	Kern County	A	M	P	USNM 418251
About 1950	California	U	U	AS	NS, Department of Fish & Game files
1950	San Luis Obispo County	A	U	U	NS, F. C. Sibley notes
1952	Kern County	A	U	U	NS, Miller et al. 1965:58
1957	Kern County	U	U	S	NS, Miller et al. 1965:58
About 1958	Kern County	U	U	U	NS, Miller et al. 1965:58
About 1959	Santa Barbara County	A	U	S	MVZ 152977
About 1961	Kern County	U	U	U	NS, Miller et al. 1965:59
About 1961	Kern County	U	U	U	NS, Miller et al. 1965:59
27 June 1960	Kern County	A	M	U	LACM 36096
August 1960	Ventura County	U	U	U	Fillmore High School (skeleton)
11 August 1960	Kern County	I	U	U	MVZ 151086
Fall 1960	Kern County	U	U	S	NS, Miller et al. 1965:59
23 September 1963	Kern County	A	U	U	MVZ 151087
23 May 1965	Fresno County	I	U	AS	MVZ 156102
August 1965	Kern County	I	U	U	NS, U.S. Forest Service files
December 1965	San Benito County	U	U	U	USNM 489406
27 October 1966	Ventura County	I	U	AS	USNM 489359

Table A-1.(Con't.) *Documented Losses of California Condors, 1792-1976.*

Date	Location	Age	Sex	Cause	Reference
February 1967	Ventura County	I	U	AS	Los Angeles Zoo, alive
Fall 1972	San Luis Obispo County	A	U	U	NS, Wilbur field notes
Fall 1972	San Luis Obispo County	A	U	U	NS, Wilbur field notes
Fall 1974	Kern County	I	U	U	USNM skeleton
Fall 1976	Kern County	A	F	S	USNM

The following specimens have uncertain collection dates, and are referred to the earliest possible time period (e.g., when they were entered in museum collections, when cited in the literature). Some may be specimens that correspond to previously listed records.

Date	Location	Age	Sex	Cause	Reference
Before					
1827	Unknown	A	U	MC	Leiden NHM
1849	California	I	U	MC	ANSP 41
1857	Unknown	A	F	MC	Brussels (Belgium) NHM
1857	Unknown	A	M	MC	Brussels NHM
1856	California?	I	U	MC	Paris NHM
1858	California?	A	U	MC	Paris NHM
1858	California?	A	U	MC	Paris NHM
1884	San Diego County	I	U	OC	LACM partial skin
1887	San Diego County	U	U	S	NS, F. Stephens records
1890	Unknown	I	U	MC	USNM 370921
1894	Unknown	U	U	MC	CAS destroyed
1894	Unknown	U	U	MC	CAS destroyed
1894	Unknown	U	U	MC	CAS destroyed
1894	Unknown	U	U	MC	CAS destroyed
1894	Unknown	U	U	MC	CAS destroyed
1897	Unknown	A	M	MC	Carnegie Museum
1897	Unknown	A	M	MC	Carnegie Museum
1899	Unknown	U	U	MC	ANSP 38325 (skeleton)
1899	Unknown	U	U	MC	ANSP 38326 (skeleton)

Before 1899	Unknown	U	U	MC	ANSP 42 (no longer in museum?)
1900	Ventura County	I	U	S	San Bernardino Museum
1904	Unknown	A	M	MC	Gothenburg (Sweden) NHM 4196
1904	Unknown	A	F	MC	Gothenburg NHM 4197
1904	Monterey County	A	U	MC	Geneva (Switzerland) NHM
1906	Unknown	A	U	MC	AMNH
1910	California	A	U	MC	Cincinnati NHM
1914	Unknown	U	U	U	MVZ 23459 (skeleton)
1929	Unknown	A	U	MC	LACM 16713A
1929	Unknown	I	U	MC	LACM 16713
1937	Unknown	I	U	U	Kern County Museum, Bakersfield
1938	Kern County	I	U	S	Bakersfield (California) College
1939	California	I	U	MC	AMNH 45068
1939	California	I	U	MC	AMNH 70298
1939	California	A	U	MC	AMNH
1939	Unknown	A	U	MC	HMCZ
1946	Unknown	A	U	MC	Reading (Pennsylvania) Museum 46-53-1

No collection dates are available for the following specimens. Some are probably specimens that go with mortality records listed above.

	Unknown	U	U	U	Milwaukee NHM 5764 (skeleton)
	Unknown	A	U	MC	Tring (England) Museum
	Southern California	A	F	MC	HMCZ 135407
	Riverside County	I	M	MC	HMCZ 80169
	Unknown	A	U	MC	AMNH 2806
	California	U	U	U	USNM 3369 (skeleton)
	San Diego County	I	F	MC	Denver NHM 16354
	Unknown	A	U	MC	Denver NHM 25546
	Unknown	A	U	U	CAS 34590
	Unknown	A	U	U	Arthur Bryant collection, Los Angeles
	Unknown	A	U	MC	CFM
	Baja California	A	U	U	National Museum, Mexico

Table A-1.(Con't.) *Documented Losses of California Condors, 1792-1976.*

Date	Location	Age	Sex	Cause	Reference
	Unknown	A	U	MC	Roger Williams Museum, Providence, Rhode Island
	Unknown	A	U	MC	Roger Williams Museum
	Unknown	U	U	U	LACM Bi-575 (skeleton)
	Unknown	A	U	U	LACM
	Unknown	A	U	MC	LACM
	Unknown	A	U	U	LACM
	Ventura County	U	U	U	LACM Bi-269 (skeleton)
	Unknown	A	U	OC	CAS 34591
	California	A	U	MC	Cincinnati NHM

Table A-2. *Documented Losses of California Condor Eggs, 1859-1943.*[a]

Date	Location	Reference[b]
28 April 1859	Monterey County	BM 1955.5.5
Before 1874	Monterey County	USNM 9983
Before 1880	Monterey County	SLU, formerly ANSP
July 1879	Santa Cruz County	CFM 2909 (part 1)
July 1879	Santa Cruz County	CFM 2902 (part 2)
April 1883	Monterey County	Florida State Museum
April 1883	Monterey County	Florida State Museum
April 1883	Monterey County	Florida State Museum
1886	San Diego County	WFVZ
10 March 1888	Santa Barbara County	Santa Barbara NHM
May 1889	San Luis Obispo County	WFVZ
February 1892 (1895?)	San Diego County	AMNH
25 April 1893	Unknown	Denver NHM
22 April 1895	Monterey County	USNM 29256
16 (25?) April 1895	San Luis Obispo County	SLU, Shields 1895
28 April 1895	Monterey County	USNM 28052
7 April 1896	Monterey County	Peabody Museum (Yale) 4151
21 April 1896	Santa Barbara County	HMCZ 4041, Wilcox 1901
11 March 1897	San Diego County	ANSP
29 April 1897	Santa Barbara County	BM 760, Anonymous 1898
9 March 1898	San Luis Obispo County	SLU, W. L. Chambers correspondence
26 March 1898	San Luis Obispo County	SLU, W. L. Chambers correspondence
3 April 1898	San Luis Obispo County	WFVZ
6 April 1898	San Benito County	SLU, Willett 1931
26 April 1898	San Luis Obispo County	AMNH 8077
17 April 1899	Santa Barbara County	HMCZ 8454
17 February 1900	Monterey County	USNM 29251
19 February 1900	Monterey County	USNM 29254

Table A-2. (Con't.) *Documented Losses of California Condor Eggs, 1859-1943.*

Date	Location	Reference[b]
4 March 1900	San Diego County	CFM 15033
19 March 1900	Monterey County	SLU, Anonymous 1900
26 March 1900	San Luis Obispo County	CFM 6165, Anonymous 1900
11 April 1900	Los Angeles County	WFVZ
22 April 1900	Monterey County	SLU, Norris 1926
24 April 1900	San Luis Obispo County	SLU, Chambers correspondence
1 March 1901	Monterey County	MVZ
11 April 1901	Santa Barbara County	HMCZ 8455
25 February 1902	San Diego County	SLU, R. Quigley correspondence
9 March 1902	Santa Barbara County	HMCZ 8453
16 March 1902	Monterey County	San Diego NHM 2137
20 March 1902	Santa Barbara County	AMNH 6937
May 1902	Ventura County	SLU, Chambers correspondence
18 May 1902	Santa Barbara County	HMCZ 8451
18 May 1902	Santa Barbara County	SLU, Chambers correspondence
25 May 1902	Ventura County	CFM 16517
11 February 1903	San Luis Obispo County	SLU, Chambers correspondence
25 March 1905	Monterey County	HMCZ 8449
12 April 1905	Monterey County	WFVZ
October 1905	Ventura County	HMCZ 8450
2 April 1906	Ventura County	BM 1941.1.6.761
10 February 1907	Los Angeles County	SLU, Koford 1953:83
27 February 1907?	San Luis Obispo County	SLU, Koford 1953:83
1 March 1908	San Luis Obispo County	R. L. More, Vernon, Texas
12 May 1909	San Luis Obispo County	HMCZ 8447
4 May 1910	Merced (San Benito?) County	Oakland (California) Museum
4 April 1915	Ventura County	CFM 6164
19 March 1916	Ventura County	Denver NHM
20 March 1917	Ventura County	S. Peyton, Fillmore, California

19? April 1917	San Luis Obispo County	University of Puget Sound
23 March 1919	Ventura County	San Bernardino County Museum
12 March 1920	San Luis Obispo County	ANSP 334
28 May 1920	Ventura County	LACM D576
June 1920	Ventura County	SLU, Koford 1953:85
6 March 1921	Ventura County	WFVZ
17 March 1921	Ventura County	SLU, M. C. Badger field notes
1922	Ventura County	Egg broken, NS, Koford 1953:83
1922	Ventura County	SLU, Koford 1953:83
21 April 1922	Ventura County	CAS 3848
16 March 1939	Ventura County	WFVZ
21 March 1943	Ventura County	WFVZ

Data are incomplete for the following eight eggs. Undoubtedly some of them are the same as those labeled "specimen location unknown" above.

Unknown	Unknown	Carnegie Museum
Unknown	Unknown	Delaware NHM
Unknown	Unknown	Delaware NHM
Unknown	Santa Barbara County	CFM 848
Unknown	Santa Barbara County	MVZ 7534
Unknown	Unknown	Santa Barbara NHM
Unknown	Unknown	Zoological Society of Cincinnati

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[a] An egg described as collected in Baja California before 1924 (Swann 1924) has not been located. Eggs laid by captive California condors are currently held by WFVZ; Mr. Nelson Hoy, Media, Pennsylvania; Delaware NHM; and USNM (seven eggs). The location of a final egg of the captive condors is unknown.

[b] See Appendix II (page 71) for abbreviations.

Table A-3. *Chronological summary of losses of California condors (numbers at left in each hyphenated pair) and condor eggs (numbers at right).*

	Period									
Location of loss	Before 1800	1800-1819	1820-1829	1830-1839	1840-1849	1850-1859	1860-1869	1870-1879	1880-1889	1890-1899
Oregon and Washington	—	5-0	5-0	1-0	—	1-0	—	—	—	—
Baja California	—	—	—	—	5-0	—	—	—	3-0	—
California[a]										
North of San Francisco	—	—	—	—	—	—	—	—	2-0	1-0
Monterey, Santa Cruz, Santa Clara, San Benito	1-0	—	—	1-0	—	4-1	3-0	1-2	9-3	20-4
San Luis Obispo	—	—	—	—	—	—	—	—	2-1	3-5
Santa Barbara	—	—	—	—	—	—	—	—	3-1	8-3
Ventura	—	—	—	—	—	—	—	—	—	3-0
Los Angeles, Orange, Riverside, and San Bernardino	—	—	—	—	—	—	—	1-0	2-0	7-0
San Diego	—	—	—	—	—	—	—	1-0	5-1	12-2
Kern, Tulare, and Fresno	—	—	—	—	—	—	—	1-0	—	3-0
Unknown	—	—	—	—	4-0	1-0	—	1-0	1-0	6-1
Totals	1-0	5-0	5-0	2-0	9-0	6-1	3-0	5-2	27-6	63-15

Table A-3. (Con't.) *Chronological summary of losses of California condors (numbers at left in each hyphenated pair) and condor eggs (numbers at right).*

Location of loss	Period 1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1976	Unknown	Total
Oregon and Washington	—	—	—	—	—	—	—	—	—	12-0
Baja California	5-0	—	—	3-0	—	—	—	—	1-1	17-1
California[a]										
North of San Francisco	1-0	—	—	—	—	—	—	—	—	4-0
Monterey, Santa Cruz, Santa Clara, San Benito	2-8	1-1	—	—	—	—	1-0	—	1-2	44-21
San Luis Obispo	1-6	1-1	0-1	—	1-0	2-0	—	2-0	—	12-14
Santa Barbara	7-5	—	2-0	3-0	—	1-0	—	—	—	24-9
Ventura	8-4	9-4	10-7	3-1	4-1	—	3-0	—	2-0	42-17
Los Angeles, Orange, Riverside, and San Bernardino	7-2	1-0	—	—	1-0	—	—	—	1-0	20-2
San Diego	3-2	—	—	—	—	—	—	—	4-0	25-5
Kern, Tulare, and Fresno	2-0	1-0	—	3-0	5-0	4-0	8-0	2-0	—	29-0
Unknown	7-0	2-0	1-0	—	—	1-0	—	—	47-0	71-1
Totals	43-27	15-6	13-8	12-1	11-1	8-0	12-0	4-0	56-3	300-70

[a] Counties, unless otherwise indicated.

Table A-4. *Causes of loss of California condors.*

	Cause of loss							
Period	Shooting	Museum related collecting	Other purposeful capture	Accidental trapping	Accident or sickness	Poison	Unknown	Total
Before 1800		1						1
1800-19	3	2						5
1820-29		5						5
1830-39		2						2
1840-49	3	4	2					9
1850-59	1	5						6
1860-69		2	1					3
1870-79	2	3						5
1880-89	5	20	2					27
1890-99	3	48	6		3	2	1	63
1900-10	7	27	8				1	43
1910-19	2	9	2				2	15
1920-29	2	8	1		2			13
1930-39	3			1	5		3	12
1940-49	3			1	4		3	11
1950-59	2				1	1	4	8
1960-69	1				3		8	12
1970-76	1						3	4
Unknown	3	41	2				10	56
Totals	41	177	24	2	18	3	35	300

APPENDIX III

Unpublished Material on the California Condor

Borneman, J. C. Field notes 1965-1976. Author's files, National Audubon Society, Ventura, California.

Carrier, W. D. Field notes 1971-1973. Copies included in condor research files, U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center.

Chambers, W. L. Correspondence, list of condor eggs in collections. Bancroft Library, Berkeley, California.

Easton, R. E. Miscellaneous notes and letters pertaining to condors in Santa Barbara County. Santa Barbara Museum of Natural History.

Hill, Harold M. Condor trip notes, Los Padres National Forest 1945-1946. Copies in Fish and Wildlife Service condor research files, Ojai, California.

Hill, Herbert. Condor nesting reports 1950-1952, 1955. Los Padres National Forest, Goleta, California.

Koford, C. B. Original field notes on condor research 1939-1941, 1946-1950. Museum of Vertebrate Zoology, Berkeley, California.

McMillan, E. Original field notes on condor research 1963-1964. Museum of Vertebrate Zoology, Berkeley, California.

Mercado, A. Original field notes on condor study, Los Padres National Forest, July-August 1975. Copies included in condor research files, Fish and Wildlife Service, Ojai, California.

Robinson, C. S. Reports and notes 1936-1940. U.S. Forest Service, Los Padres National Forest, Goleta, California.

Scott, C. D. Manuscript (1935, 1945) "Looking for Condors." Huntington Library, San Marino, California.

Sibley, F. C. Original field notes and administrative reports 1966-1969. Fish and Wildlife Service, Patuxent Wildlife Research Center.

Sprunt, A. Report on trip to Sespe Condor Sanctuary, March-April 1961. National Audubon Society, New York.

Todd, F. S. Manuscript (1971) "Notes on the behavior of Topatopa," a captive condor. Author's files, Sea World, San Diego, California.

U.S. Bureau of Land Management. Public hearing record on Sespe Condor Sanctuary withdrawal, 21 August 1950. 3 volumes, 443 pp. Bureau of Land Management, Sacramento, California.

U.S. Forest Service. Condor patrolman reports, Los Padres National Forest, Goleta, California. R. Davis (March 1951); B. F. Dahlen (March-May 1952); W. Kastorff (July-Aug. 1952); W. M. Harper (March 1956-June 1959); J. W. Gaines (July 1959-March 1964); Y. D. Miller (April 1964-April 1966); and D. L. Connell (June 1966-June 1967).

Van Vuren, D. Manuscript "Deer hunters and the California condor: activity patterns and possible conflicts at Mount Pinos and Pine Mountain, Ventura County, California" (1975). Copy plus original field notes from study included in condor research files, U.S. Fish and Wildlife Service, Ojai, California.

Wilbur, S. R. Original field notes and administrative reports 1969-1976. U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center.

Work, T. Condor trip reports, Los Padres National Forest, 1945-1946. Copies with Fish and Wildlife Service condor research files, Ojai, California.

APPENDIX IV

Chronology of Significant Events in California Condor History

1602—First written record of the California condor, Monterey, California (de la Ascension 1928).

1792—First condor known collected, by Archibald Menzies, at Monterey, California; specimen still in British Museum.

1885—Possibly a State of California law passed about this time, indirectly prohibiting or limiting the killing of condors or taking of their eggs (Cooper 1890); no particulars found.

1905—Section 637a, California Fish and Game laws (approved 19 March) prohibited taking of nongame birds, their nests, or eggs without a permit (condor included, but not specifically named). Fish and Game Commission made formal statement concerning prohibition on condor collecting (Anonymous 1905).

1906—W. L. Chambers compiled a list of condor eggs in collections, copy on file at Bancroft Library, Berkeley, California.

1908—Condor shot in Los Angeles County, shooter fined $50 (Grinnell 1909), apparently the only instance of condor killing or egg taking leading to prosecution and conviction.

1917—Illegally captured condor confiscated in Monterey County, but apparently no prosecution (Anonymous 1917).

1937—Sisquoc Condor Sanctuary, including approximately 485 ha (1,200 acres), established by U.S. Forest Service under Regulation T-9.

1939—Carl B. Koford began intensive studies of California condor, sponsored by research fellowship from National Audubon Society.

1901—State of California Legislature enacted "protective laws," protecting all birds of prey except peregrine falcon (*Falco peregrinus*), Cooper's hawk (*Accipiter cooperi*), and sharp-shinned hawk (*Accipiter striatus*).

1940—Cyril S. Robinson, U.S. Forest Service, prepared the first research report on the condor, the result of observations made in 1936-1940 (Robinson 1940).

1941—Harry Harris published a comprehensive historical account of the condor (Harris 1941).

1942—Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (the "Natural Resources Treaty") recognized the condor as being in serious trouble; no legal status conferred by the treaty.

1947—Sespe Condor Sanctuary, approximately 14,000 ha (35,000 acres), established by U.S. Forest Service under Regulation T-9.

1948—California Condor Advisory Committee established to advise Los Padres National Forest on condor management.

1949—International Technical Conference on the Protection of Nature, Lake Success, New York: 13 world birds, including the condor, recognized as needing emergency help.

1951—Sespe Condor Sanctuary enlarged to 21,450 ha (53,000 acres) by Forest Service; Public Land Order 695 withdrew a portion of the area from appropriation under public land laws, and prohibited surface entry in areas most critical to the condors.

1951—First patrolman (part-time) assigned to Sespe Condor Sanctuary; Forest Service and National Audubon Society shared salary costs.

1952—Sespe Wildlife Sanctuary Management Plan approved.

1953—Publication of Carl B. Koford's research as National Audubon Society Research Report 4.

1953—First legal protection specifically directed to the condor. Section 1179.5, California Fish and Game Code: "It is unlawful to take any condor at any time or in any manner. No provision of this code or any other law shall be construed to authorize the issuance of a permit to take any condor and no such permit heretofore issued shall have any force or effect for any purpose on and after January 15, 1954."

1956—First full-time patrolman (William M. Harper) assigned to Sespe Condor Sanctuary by U.S. Forest Service.

1959—California Fish and Game Code, Section 3511, California condor among those species listed as "fully protected," those that cannot be taken at any time; no authority for issuing any type of permit. Fine of $500 or 6-month jail sentence authorized.

1965—Publication of National Audubon Society Research Report 6, condor status report based on 1963-1964 field work of Ian I. McMillan and Eben McMillan (Miller et al. 1965).

1965—Condor Advisory Committee formalized; task enlarged to one of advising Regional Forester on all condor matters.

1965—Assignment by National Audubon Society of Condor Naturalist (originally "condor warden") John C. Borneman to full-time educational and field study program.

1965—Endangered Wildlife Research Program initiated at Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service; Fred C. Sibley assigned to full-time research on the condor, succeeded in 1969 by Sanford R. Wilbur.

1965—California Senate Bill 261 signed into law, increased penalty for taking a condor to $1,000 and 1 year in jail.

1965—First Cooperative Survey of the California condor, the first attempt at simultaneous observation of condor numbers and distribution.

1966—Formation of Condor Survey Committee to act as technical advisors in condor research and management; name subsequently changed to Condor Technical Committee, then to Condor Recovery Team.

1966—Passage of Endangered Species Preservation Act (80 Stat. 926), directing Secretary of the Interior to develop a register of endangered species, and authorizing expenditure of Land and Water Conservation Fund monies (78 Stat. 897) for endangered species habitat acquisition.

1967—First official list of United States endangered species published by Secretary of the Interior, condor included.

1968—U.S. Forest Service assigned wildlife biologist W. Dean Carrier to condor investigations, position filled until November 1973.

1969—Passage of Endangered Species Conservation Act (Public Law 91-135) prohibited interstate shipment of wildlife taken contrary to State law.

1970—State of California Endangered Species Act passed, condor subsequently (1971) officially listed as "endangered" under State law.

1970—Secretary of Interior took stand against Sespe Water Project because of expected detrimental effects on condor.

1970—California Department of Fish and Game prepared "Operational management plan for the California condor" (Mallette 1970), guidelines for preservation, management, and further research.

1970—Secretary of the Interior placed moratorium on oil and gas leasing in the Sespe Condor Sanctuary.

1970—U.S. Bureau of Land Management placed moratorium on all mineral leasing activities within area delineated as especially important to condor survival.

1971—Forest Service prepared "Habitat management plan for the California condor" (Carrier 1971), specific guidelines for condor preservation on national forest lands.

1971—California Fish and Game Code, Section 3511, amended (Stats. 1970, Ch. 1036) to allow issuance of permits for collecting fully protected species, including condor, when necessary for scientific research.

1971—Acquisition by Nature Conservancy and Forest Service of 65-ha (162-acre) Huff's Hole property, San Luis Obispo County, important for protection of a condor nesting area.

1972—Migratory bird treaty with Mexico (1937 Convention) amended; California condor among species added to protected bird list; first specific Federal protection of the condor.

1972—Firearms closure for Sespe Condor Sanctuary and adjacent condor habitat established by Forest Supervisor, Los Padres National Forest.

1973—California Assembly Bill 15 passed, prohibiting all aircraft flight within 915 m (3,000 feet) of terrain over the Sespe Condor Sanctuary (Fish and Game Code 10501.5).

1973—Passage of Endangered Species Act of 1973 (Public Law 93-205) made taking of any endangered species a violation of Federal law, and strengthened authority and responsibility of all Federal agencies in protecting endangered species and preserving critical habitat.

1973—Acquisition of an important private inholding in the Sespe Condor Sanctuary, the 130-ha (320-acre) Green Cabins parcels, by National Audubon Society.

1975—Acquisition of the 23-ha (58-acre) Coldwater Canyon tract within the Sespe Condor Sanctuary, by California Department of Fish and Game.

1975—Acquisition of 728-ha (1,800-acre) Hopper Mountain National Wildlife Refuge by U.S. Fish and Wildlife Service, as protective buffer for the Sespe Condor Sanctuary and as condor feeding habitat.

1975—Approval of California Condor Recovery Plan, and formal recognition of Condor Recovery Team.

APPENDIX V

An Annotated List of California Condor Literature

Abbott, J. A. 1939. Eggs: $9,000.00 a dozen. Los Angeles Times Magazine, 14 May:14.

A 1922 egg list values condor egg at $750.00.

Advisory Committee on Predator Control. 1972. Predator control — 1971. Report to the Council on Environmental Quality and the Department of the Interior. 207 pp.

Page 86, brief review of condor — predator control relationships; few cases of condor deaths, but "the strong possibility of secondary poisoning."

Ainsworth, E. 1937. Condors come back; expert tells habits. Los Angeles Times, 28 March.

Condors reputedly increasing at rapid rate, no details.

Ainsworth, E., 1954. Condor crusade. Field and Stream 59(2):46-49.

Alleges only about 38 condors in existence, not more than 8 or 10 nesting pairs.

Allen, A. S. 1916. [Cooper Ornithological Society meeting notes.] Condor 18(4):175.

Dr. Evermann saw "half a dozen" condors in Ventura County.

Allen, T. B. 1974. Vanishing wildlife of North America. National Geographic Society, Wash., D.C. 207 pp.

Pages 157-164, summary of recent research and management.

American Ornithologist's Union. 1940. Report of the Committee on Bird Protection, 1939. Auk 57(2):279-291.

Reports 3-year Audubon fellowship study initiated; Sisquoc Condor Sanctuary established, closed to public ingress.

American Ornithologist's Union. 1941. Report of the Committee on Bird Protection, 1940. Auk 58(2):292-298.

Estimated 50 condors in existence; Committee proposed (1) setting aside entire Los Padres National Forest for condor protection, (2) prohibiting all hunting, except for personnel killing deer for condor food, and (3) restoring the mountain lion population on the Forest so that lion kills would be available to condors.

American Ornithologist's Union. 1942. Report of the Committee on Bird Protection, 1941. Auk 59(2):286-299.

Condor population thought to have increased by 10% in past 2 years (C. B. Koford, personal communication).

American Ornithologist's Union. 1943. Report of the Committee on Bird Protection, 1942. Auk 60(1):152-162.

War Department closed entire Los Padres Forest to public entry; condors believed to be increasing and expanding their range; D. D. McLean reputedly saw 80 condors early in 1942.

American Ornithologist's Union. 1944. Report of the Committee on Bird Protection, 1943. Auk 61(4):622-635.

Condors reputedly increased during past year.

American Ornithologist's Union. 1965. Report of the Committee on Bird Protection, 1964. Auk 82(3):490.

Proposed Sierra Madre Ridge Road and Sespe Creek water project viewed as threats to condors.

American Ornithologist's Union. 1971. Report of the Committee on Conservation, 1970-71. Auk 88(4):902-910.

Notes that data on condor status are confusing, population estimates varying from about 30 to more than 60.

Anderson, N. T. 1935. Condors in northern Los Angeles County, California. Condor 37(3):170.

Antelope Valley, 9 August 1934, seven condors feeding on sheep carcass; December 1934-January 1935, four records (one to three condors).

Anonymous. 1854. [Accession notes, 1855.] Proc. Calif. Acad. Sci. 1:70-71.

Condor specimen acquired from W. B. Farwell, no details; condor feathers received from A. C. Taylor, collected "in the vicinity of the Red Woods of Contra Costa."

Anonymous. 1874. [Minutes of 3 March 1873 meeting.] Proc. Calif. Acad. Sci. 5:36-37.

"Mr. Lorquin" described immature condor captured by him, date and place not given.

Anonymous. 1893. Additions to the Museum for the Year 1892. Proc. Calif. Acad. Sci., Ser. 2, 3:379-382.

Academy received a mounted condor specimen from G. E. Colwell of San Francisco.

Anonymous. 1894a. Three thousand bird skins. Nidiologist 2(4):55.

Walter E. Bryant collection, including five condor skins, given to California Academy of Sciences.

Anonymous. 1894b. Notes and news. Nidiologist 2(4):51.

G. F. Breninger reports two condor sightings (one bird each) near Pacheco Pass, Merced County (no date), and three condors in Santa Cruz County "last summer."

Anonymous. 1896. How the condor is captured. Littell's Living Age 209(2709):640.

Dramatic account of a condor being lassoed and captured, no date or location given.

Anonymous. 1898. Notes on the taking of an egg of the California condor. Museum 4(7):103.

Condor egg collected in Santa Barbara County, 29 April 1897.

Anonymous. 1899. [Correspondence from A. F. Redington.] Bull. Cooper Ornithol. Club 1(1):19.

One condor seen at San Marcos Pass, Santa Barbara County; "We can almost guarantee at least the sight of this species in a day's trip down the Santa Ynez range."

Anonymous. 1900a. Two more eggs of California condor. Condor 2(3):60.

H. R. Taylor's collectors secured condor eggs on 19 March 1900 (Monterey Cty.) and 26 March 1900 (San Luis Obispo Cty.); sold to Miss Jean Bell of Pennsylvania.

Anonymous. 1900b. Eggs of the California condor. Osprey 4(9):142.

H. M. Beesley trying to purchase condor egg for Tring (England) Museum; last recorded sale reportedly in 1887. "There are said to be several oologists who are ready to pay $1,000 to $1,200 for an egg."

Anonymous. 1901. [Report of condor death.] Condor 3(3):79.

F. H. Holmes pet condor "Ben Butler" died of undetermined causes after several years captivity.

Anonymous. 1904. Notes and News. Condor 6(3):83.

Trip into western Los Angeles and Ventura counties by Messrs. Lelande and Howard, on which 11 condors were seen simultaneously "and several nesting aeries were located."

Anonymous. 1905. Annual report of the National Association of Audubon Societies for 1905. Bird-lore 7(6):295-350.

Citing California newspaper: "The (California) Fish and Game Commission has announced that no permits will be issued for collecting the California Condor or its eggs for any purpose."

Anonymous. 1906. The California vulture. Birds Nat. 4(5):188.

General compilation.

Anonymous. 1907. An almost extinct bird. N.Y. Zool. Soc. Bull. 24:318-320.

W. L. Finley's condor "General" acquired by New York Zoo.

Anonymous. 1916. List of accessions to the Museum and Library, 1916. Proc. Calif. Acad. Sci., Ser. 4, 6(8-9):246-250.

Presentation to the Academy of two condor specimens collected by E. B. Towns, January 1894, in San Diego County.

Anonymous. 1917. California condor on exhibition in Golden Gate Park, San Francisco, Calif. Fish Game 3(4):176.

Condor lassoed in Monterey County, confiscated and placed on exhibition by Fish and Game Commission.

Anonymous. 1922. Proceedings of the annual meeting, Audubon Association of the Pacific. Gull 4(2):1-2.

C. Littlejohn notes that in San Mateo County and vicinity "Condors were quite common in the early days. Flocks of buzzards would include one condor in twenty birds."

Anonymous. 1926. Bird that lays $1,500 eggs. Lit. Dig. 90(6):48, 52.

Condor "lays an egg valued by museums and collectors at $1,500 to $2,000"; only 50 condors remaining, California Fish and Game Commission records.

Anonymous. 1927. [Editorial on "Bird that lays $1,500 eggs." Anon. 1926.] Condor 29(3):129.

Notes numerous misstatements, and criticizes drawing attention to the value of eggs.

Anonymous. 1928. Pet condor as cute as a canary. Lit. Dig. 97(5):45-46, 48, 50.

Good general account of W. L. Finley's condor "General."

Anonymous. 1929. Youth fights condor to win thousand dollar egg. Pop. Mech. 52(5):708.

Condor egg allegedly collected in Baja California. See Lume 1938.

Anonymous. 1930. Science news: items. Science 71(Suppl. 1840):14.
Condor wing bone found in Conkling Cave, New Mexico.

Anonymous. 1937a. The condor, largest flying bird, faces extinction. Calif. Conserv. 2(9):5.
Fantastic information: Condor "mates for life and if anything happens to either one, the survivor never takes another mate . . . lays an average of one egg every four years . . . The young remain in the nest for more than a year before they can fly. During that time the eagle is the condor's one and only enemy."

Anonymous. 1937b. Condor upturn. Time 29(15):51.
Sidney Peyton saw 11 condors in Sespe area of Los Padres Forest; his opinion is that condors are increasing.

Anonymous. 1951a. The condors' last stand. Life 30(15):75-77.
Picture story of condor in Los Padres Forest; one photo shows seven condors at roost.

Anonymous. 1951b. Frank Arundell, county naturalist, admits with candor he knows condor. Ventura County News, 18 Janaury:6.
Early-day egg and skin collecting activities reported.

Anonymous. 1953. To catch a condor. Newsweek 41(19):92.
Account of attempts by San Diego Zoo to capture condors for captive propagation.

Anonymous. 1960. [Field observation.] Gull 42(8):56.
One adult condor seen near Lebec, Kern County, 3 May 1960.

Anonymous. 1964a. Last of the shy condors. Life 57(22):75-76.
Picture story.

Anonymous. 1964b. Condor in danger. Defenders Wildl. News Bull. 39(3):9.
"A group of volunteers are forming to patrol their (the condors') roosting, nesting and feeding areas"; opposition to Sierra Madre Ridge Road proposal.

Anonymous. 1965a. A Topatopa Dam could destroy the condor. Audubon Leader's Conserv. Guide 6(1):1-2.
Review of the proposed Sespe Water Project.

Anonymous. 1965b. Condor census — "38 probables." Outdoor Calif. 26(11):16.
Results of First Cooperative Condor Survey.

Anonymous. 1965c. Condor population declines from 60 to 40; gunners blamed. Defenders Wildl. 40(1):61-62.
Review of Miller et al. 1965a.

Anonymous. 1965d. Condor killed. Audubon Leader's Conserv. Guide 6(14):3.
Photo of powerline mortality.

Anonymous. 1966. Wilderness and the condor. Natl. Parks Mag. 40(220):19-20.
San Rafael Wilderness and the condor.

Anonymous. 1967. Condors may disappear. My Weekly Reader 36(24):1, 4.
Brief children's article.

Anonymous. 1968. The Audubon view — condors, whooping cranes and Audubon policy. Audubon Mag. 70(6):4.

Captive propagation viewed as a research technique and as a "last ditch" effort to preserve a population.

Anonymous. 1973. To save a bird. Aerosp. Saf. 29(9):11.

Plea for pilots to avoid condor nesting areas.

Anonymous. 1974. Condor Fund drive; seeing the California condor. West. Tanager 41(3):1-2.

Where to see condors.

Anonymous. 1976. Second stage of condor breeding program nears completion. Endangered Species Tech. Bull. 1(5):2, 4.

History of Andean condor propagation at Patuxent Wildlife Research Center. Birds captured in 1966-67 all paired, three of four pairs have produced young. Eventually captive-reared condors are to be released to the wild.

Anthony, A. W. 1893. Birds of San Pedro Martir, Lower California. Zoe 4(3):228-247.

Condors seen daily in May 1893, two dead ones found; saw condor quills used for carrying gold dust.

Anthony, A. W. 1895. Birds of San Fernando, Lower California. Auk 12(2):134-143.

One condor found dead; condors unusual in that area.

Arnold, R. 1909. Condors in a flock. Condor 11(3):101.

Eighteen condors seen near McKittrick, Kern County, 1 October 1908; only two or three condors seen by him in that area in 2 years.

Ashworth, C. W. 1929. California condor. Oologist 46(5):65-66.

Four condors seen 6 miles from Ventura, California, 24 March 1929.

Atkinson, B. 1966. Those "Forty dirty birds." Audubon Mag. 68(4):231-237.

Popular account of life history and status.

Atkinson, B. 1972. "40 dirty birds" hold their own but are never safe. Smithsonian 2(12):66-73.

Popular account, well done.

Audubon, J. J. 1839. Ornithological biography. Vol. 5. Adam and Charles Black, Edinburgh. 664 pp.

Pages 240-245, life history notes from various sources.

Audubon, J. W. 1906. Audubon's western journal, 1849-1850. Arthur H. Clark, Cleveland. 249 pp.

Records of condors in San Diego County (November 1849) and San Joaquin Valley, California (November or December 1849, "many"; March-April 1850, several records; thought he saw nests, but record not certain).

Austin, M. 1974. The land of little rain. Reprint of 1903 edition. University of New Mexico Press, Albuquerque. 171 pp.

Undated records of condors at Tejon Ranch and Red Rock Canyon, Kern County.

Baird, S. F., T. M. Brewer, and R. Ridgway. 1874. A history of North American birds. Vol. 3, land birds. Little, Brown and Co., Boston. 560 pp.

Pages 338-343, good compilation from various sources.

Baker, J. H. 1946. Condor research to be resumed. Audubon Mag. 48(1):53-54.

Notes return of C. B. Koford to finish condor studies; lauds national forest fire closure because it reduces public use of condor areas.

Baker, J. H. 1950a. Better protection for the California condor. Audubon Mag. 52(6):348-354.

Recommendation that Department of Interior close Sespe area to mining and mineral leasing.

Baker, J. H. 1950b. Oil and condors don't mix. Audubon Mag. 52(2):120.

Proposes Sespe mining closure.

Baker, J. H. 1951. Condor prospects improve. Audubon Mag. 53(2):122-123.

Passage of Public Land Order 695, and establishment of Sespe Condor Sanctuary; full text of land order.

Baker, J. H. 1953. Threat to the condors. Audubon Mag. 55(2):68.

Protests issuance of permit to San Diego Zoo to trap condors.

Bancroft, H. H. 1882. The native races. Vol. 3, myths and legends. A. L. Bancroft and Co., San Francisco. 796 pp.

Page 134, general comments on American Indian religion and condor; page 168, description of the "panes" festival, involving sacrificing a condor.

Barnes, R. M. 1912. California condor's egg. Oologist 29(5):269.

Condor egg from San Diego County; details in Gedney 1900.

Barnes, R. M. 1913. Condor of United States. Oologist 30(1):13-14.

Quotes fanciful magazine information from *Youth's Companion*, decries printing of such misinformation in "any reputable publication."

Barnes, R. M. 1931. The California condor. Oologist 48(12):175.

One condor reported from Beverly Hills, Los Angeles County, 11 November 1931.

Beebe, C. W. 1906. The California condor. Bull. Zool. Soc. N.Y. 20:258-259.

Description of live condor in New York Zoo.

Beebe, C. W. 1909. New World vultures. Part II. N.Y. Zool. Soc. Bull. 32:465-470.

Mainly a description of W. L. Finley's condor "General." Beebe adds, "I have carefully tested the (California condor's) power of scent . . . and if present at all it is very slight indeed."

Beebe, C. W., and L. S. Crandall. 1912. The birds of prey and their aviary. Part II. N.Y. Zool. Soc. Bull. 16(52):886-889.

Notes that New York Zoo has three California condors.

Behle, W. H. 1944. Check-list of the birds of Utah. Condor 46(2):67-87.

Condor on State list on basis of one record (Henshaw 1875).

Belding L. 1879. A partial list of the birds of central California. Proc. U.S. Natl. Mus. 1:388-449.

Sacramento Valley, California: condor "very rare," seen occasionally in winter.

Belding, L. 1890. Land birds of the Pacific district. Occas. Pap., Calif. Acad. Sci. 2:1-274.

Summarizes comments of various observers.

Bendire, C. 1892. Life histories of North American birds. Smithson. Inst. Spec. Bull. 1. 446 pp.

Pages 157-161, general comments on life history and status; attributes a major decline to poisoning, but no details given; condors noted as "moderately abundant" in "Tulare" (San Joaquin) Valley, 1866-1868.

Bent, A. C. 1937. Life histories of North American birds of prey. Part I. Bull. U.S. Natl. Mus. 167. 409 pp.

Pages 1-13, general compilation of available data.

Bidwell, J. 1964. A journey to California, 1841. The journal of John Bidwell. Friends of the Bancroft Library, Berkeley. 55 pp.

General comment (no locations given) that both "buzzards" (turkey vultures) and "vultures" (condors) are numerous in California.

Bidwell, J. 1966. Life in California before the Gold Discovery. Lewis Osborne, Palo Alto. 76 pp.

1840's — "New Mexican" miners in Los Angeles County "invariably carried their gold . . . in a large quill — that of a vulture (condor) or turkey buzzard."

Bishop, R. C. 1971. Conservation of the California condor in relation to the proposed phosphate mining and processing operation in Los Padres National Forest. Calif. Agric. Exp. Stn., Contrib. to Proj. 1244. 25 pp.

Economic analysis, concludes that "the public could legitimately question the wisdom of using public land for (a phosphate mine). . . risking an endangered species of international significance in the process . . ."

Blake, C. H. 1955. The wing of *Teratornis merriami*. Int. Ornithol. Congr. 11:261-263.

Compares flight characteristics of condor with suspected features of *Teratornis*.

Blake, W. C. 1895. Big price for a bird skin. Nidiologist 2(7):96, 2(8):122.

Condor skin sold for 40 pounds.

Bleitz, D. 1946. Climbing for condors. Pac. Pathways 1(10):37-41.

Visits to a condor nest in Ventura County mountains; nestling found dead, arsenic found during analysis; author surmises chick was fed poisoned meat by parents (but see Koford 1953:130 for another explanation).

Bock, W. 1960. Secondary articulation of the avian mandible. Auk 77(1):19-55.

Includes discussion of Cathartidae, with diagram of condor skull.

Bolander, G. 1934. A rhapsody of raptors. Gull 16(8):1-2.

Seven condors (six adults, one immature) seen in Sespe Canyon, Ventura County, 4 December 1933.

Bolton, H. E. 1927. Fray Juan Crespi, missionary explorer of the Pacific Coast, 1769-1774. University of California Press, Berkeley. 402 pp.

Page 210, description of Indian ritual involving a stuffed bird, apparently a condor.

Borland, H. 1974. Take a long, last look at the condor. Natl. Wildl. 12(3):35-36.

Popular account of condor status, some misinformation.

Borneman, J. C. 1966a. The disappearing condors of Sespe. Mod. Maturity 9(5):44-45.
General account of life history and status.

Borneman, J. C. 1966b. Return of a condor. Audubon Mag. 68(3):154-157.
Condor apparently poisoned by strychnine rehabilitated and returned to the wild.

Borneman, J. C. 1969. California condor preservation program. West. Tanager 35(7):59-60.
General progress report.

Borneman, J. C. 1970a. Condors. West. Tanager 36(7):1.
Condor-golden eagle interactions.

Borneman, J. C. 1970b. California condor newsletter. National Audubon Society, Ventura, Calif. 3 pp.
Progress report on research and management.

Borneman, J. C. 1971. California condor newsletter #2. National Audubon Society, Ventura, Calif. 3 pp.
Progress report.

Borneman, J. C. 1972. California condor newsletter #3. National Audubon Society, Ventura, Calif. 3 pp.
Progress report.

Borneman, J. C. 1973. The condor challenge. West. Tanager 39(11):3.
Changes in habitat affecting condors.

Borneman, J. C. 1974a. California condor newsletter #4. National Audubon Society, Ventura, Calif. 3 pp.
Progress report.

Borneman, J. C. 1974b. The 2:00 o'clock condor. West. Tanager 40(10):3.
Watching condors at Mt. Pinos, Ventura County.

Borneman, J. C. 1975a. California condor newsletter #5. National Audubon Society, Ventura, Calif. 1 p.
Progress report.

Borneman, J. C. 1975b. Improving the odds for survival. West. Tanager 42(2):3.
Progress in land acquisition for condors.

Borneman, J. C. 1976a. California condor newsletter #6. National Audubon Society, Ventura, Calif. 2 pp.
Progress report.

Borneman, J. C. 1976b. The California condor, year of decision. West. Tanager 43(2):3.
Discusses possibility of captive propagation program for condors.

Borneman, J. C. 1976c. The victim. Audubon Imprint (Santa Monica Bay Audubon Society) 1(4):4-5.
Attempted rehabilitation of a condor found with a broken wing, result of gunshot.

Borneman, J. C. 1976d. California condors soaring into opaque clouds. Auk 93(3):636.

Condors reported circling up into opaque stratus clouds, an occurrence seldom reported for vultures.

Brewster, W. 1882. On a collection of birds lately made by Mr. F. Stephens in Arizona. Bull. Nuttall Ornithol. Club 7(2):65-86.

Large vulture seen at Cave Creek, Chiricahua Mountains, 7 March 1881, thought to be a California condor.

Brodkorb, P. 1964. Catalogue of fossil birds. Part 2 (Anseriformes through Galliformes). Bull. Fla. State Mus., Biol. Sci. 8(3):195-335.

Pages 250-258, summary of fossil records of condor.

Brown, H. 1899. The California vulture in Arizona. Auk 16(3):272.

March 1881, describes two birds, possibly condors, seen near Pierce's Ferry, western Arizona; one was shot, measured "more than three gun lengths in the spread of its wings."

Brown, L., and D. Amadon. 1968. Eagles, hawks and falcons of the world. Vol. 1. McGraw-Hill Book Co., New York. 414 pp.

Pages 185-189, general life history summary.

Bryan, M. 1901. A study of the birds of Santiago Canyon. Condor 3(3):81-82.

Orange County, California, condors once plentiful there, but none "for twelve years or more."

Bryant, C. A. 1933. [Comments in Cooper Club meeting notes.] Condor 35(3):131.

Six condors observed in Sespe Canyon, Ventura County, 6 December 1932.

Bryant, W. E. 1889. Catalogue of the birds of Lower California. Proc. Calif. Acad. Sci., Ser. 2, 2:237-320.

Condors reported "several places" in Baja California.

Bryant, W. E. 1891. Andrew Jackson Grayson. Zoe 2(1):34-68.

July 1847, "at least a dozen" condors feeding on a deer carcass, Marin County, California.

Buchheister, C. W. 1965a. Meeting the challenges of the "third wave." Audubon Mag. 67(1):18-19.

National Audubon Society proposals to solve condor problems.

Buchheister, C. W. 1965b. Grave threat to the condor. Audubon Mag. 67(2):82-83.

Adverse report on proposed Sespe Water Project.

Buchheister, C. W. 1965c. Our campaign to save the condor. Audubon Mag. 67(3):180.

Audubon assigned naturalist to condor responsibilities; prepared identification leaflet.

Buchheister, C. W. 1965d. Crucial meeting on the condor. Audubon Mag. 67(5):285.

National Audubon reports against Sespe Creek dam proposal.

Buchheister, C. W. 1965e. Annual condor count planned. Audubon Mag. 67(6):357.
Preparations for annual survey. See Mallette and Borneman 1966 for results.

Buchheister, C. W. 1966. Help for the condor. Audubon Mag. 68(1):5.
Progress report.

Buntin, J. 1975. Effects of land development practices in Kern County upon the California condor. Kern Co. (California) Health Department. 28 pp.
Discusses condor as related to various land development proposals; recommends guidelines for development in condor habitat.

Burroughs, R. D. 1961. The natural history of the Lewis and Clark expedition. Michigan State University Press, East Lansing. 340 pp.
Summarizes 1805-06 records from Columbia River region, Oregon and Washington.

California Condor Recovery Team. 1974. California condor recovery plan. U.S. Fish and Wildlife Service. 74 pp.
Action proposal to maintain a population of at least 50 California condors, well distributed within their 1974 range, with an average annual natality of at least four birds.

California Department of Fish and Game. 1974. At the crossroads. A report on California's endangered and rare fish and wildlife. Sacramento. 112 pp.
Pages 13-14, status summary.

California Department of Fish and Game. 1976. At the crossroads, 1976: a report on California's endangered and rare fish and wildlife. Sacramento. 101 pp.
Pages 6-8, status summary.

Callison, C. H. 1966. Sespe Project setback is condor's reprieve. Audubon Mag. 68(3):161.
Ventura County voters reject water project proposal.

Callison, C. H. 1967. San Rafael and the condors. Audubon Mag. 69(3):57.
Brief history of San Rafael Wilderness hearings.

Cant, G. 1960. Condors rising. Sports Illus. 7(29):W2-W10.
General account of status.

Caras, R. A. 1970a. Source of the thunder. The biography of a California condor. Little, Brown and Co., Boston. 181 pp.
Highly fictionalized account.

Caras, R. A. 1970b. Source of the thunder. Audubon 72(6):82-84, 90-131.
Condensation of Caras 1970a.

Carrier, W. D. 1971. Habitat management plan for the California condor. U.S. Forest Service. 51 pp.
Forest Service guidelines for condor management.

Carrier, W. D. 1973. California condor, situation critical. Am. Hiker, March:32-35.
Summary of status and management.

Carrier, W. D., R. D. Mallette, S. Wilbur, and J. C. Borneman. 1972. California condor surveys, 1971. Calif. Fish Game 58(4):327-328.
Results of 1971 survey attempts.

Carver, M. 1960. [Report on a California condor captured in Kern County, California.] News from the Bird-banders 35(3):34-35.
Condor found with dislocated leg, veterinarian set leg and bird was released. (Bird died according to Miller et al. 1965a.)

Cassin, J. 1849. Special report on state of the Academy ornithological collection. Proc. Acad. Nat. Sci. Phila. 4:256-260.
E. L. Kern collected condors in California in 1845, to be added to the Academy collection.

Cassin, J. 1858. United States exploring expedition during the years 1838-1842 under the command of Charles Wilkes, U.S.N. Vol. VIII. Mammalogy and ornithology. J. B. Lippincott and Co., Philadelphia. 466 pp.
Condors seen on the plains of the Willamette River, Oregon, but "much more numerous in California."

Chambers, W. L. 1915. California condor in Los Angeles County. Condor 17(2):102.
One condor seen near Covina, 16 February 1916; "used to be very common in this range . . . seldom seen now."

Chambers, W. L. 1936. The hunter versus wildlife. Condor 38(5):199-202.
Reports two condors shot and brought to his store.

Chapman, F. M. 1908. Camps and cruises of an ornithologist. Appleton and Co., New York. 432 pp.
Pages 259-266, observations of condors and condor nests in Piru Creek area, Ventura County.

Christy, B. H. 1932. A quest for a condor. Condor 34(1):3-5.
Trip into California mountains resulted in sighting of two adult condors; no dates or places mentioned.

Clark, A. M. 1962. From grove to cove to grove, a brief history of Carpinteria Valley, California. Privately printed. 93 pp.
Fantasy. People of Carpinteria declared war on the condors after one stole a baby; they hunted them until they finally disappeared from the area.

Cleland, R. G. 1957. The place called Sespe, the history of a California ranch. San Marino, California, Huntington Library. 120 pp.
Notes that Chumash Indians in Ventura County used condor feathers in ceremonial costumes.

Clement, R. C. 1965. California condor conservation project. West. Tanager 31(7):62.
National Audubon Society hires condor naturalist.

Clement, R. C. 1966. Dangers of pessimism in conservation. Trans. N. Am. Wildl. Nat. Resour. Conf. 31:378-381.
Uses condor as an example of saving or dooming a species by attitude.

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Summarizes Miller et al. 1965a.

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Condor shot in Cuyamaca Mountains, San Diego County, presented to Museum 7 May 1880, but no taxidermist in town so the specimen was not saved.

Clyman, J. 1926. James Clyman, his diaries and reminiscences. Calif. Hist. Soc. Q. 6(2):136-137.
Napper Creek (Napa County), California, 16 August 1845, "the royal vulture in greate abundance"; 8 September 1845, killed one "royal vulture."

Cochran, D. M. 1927. California condor. Nat. Mag. 9(6):378.
Observations of condors in National Zoo.

Cohen, D. A. 1897. California department. Osprey 1(11-12):150.
Condor reportedly shot, sold to "a saloon-keeper in a country town for $2.00."

Cohen, D. A. 1898a. California notes. Osprey 2(9):120.
Condor egg reported collected for H. R. Taylor.

Cohen, D. A. 1898b. California notes. Osprey 2(10):135.
Two more condor eggs reported collected.

Cohen, D. A. 1899. Pet California condor. Osprey 3(5):78.
Photo and description of Frank Holmes' pet condor "Ben Butler."

Cohen, N. W. 1951. California condors in Madera County, California. Condor 53(3):158.
Nine condors seen at O'Neals, 30 August 1950.

Cooley, R. A., and G. M. Kohls. 1944. The Argasidae of North America, Central America and Cuba. Am. Midl. Nat., Monogr. 1:1-152.
Argas reflexus, "pigeon tick," collected near condor nests.

Cooper, J. G. 1870. Ornithology of California. Vol. 1, land birds. Welch, Bigelow and Co., Cambridge. 592 pp.
Pages 495-503, compilation of then current fact and misinformation.

Cooper, J. G. 1871. Monterey in the dry season. Am. Nat. 4(12):756-758.
August-September 1861, condor listed as one of "the most characteristic land birds."

Cooper, J. G. 1890. A doomed bird. Zoe 1(8):248-249.
May 1872, Orange County, California: one condor observed, apparently hurt or sick; general comments on apparent decline of the species.

Cooper, J. G., and G. Suckley. 1859. The natural history of Washington Territory. Bailliere Bros., New York. 399 pp.
No positive records of condor during 1853-1854, one possible.

Cooper, T. 1976. Government flimflam threatens the condor. Defenders Wildl. 51(3):204-205.
Rabid criticism of government biologists for not taking a stronger stand against a proposed phosphate mine; collusion suggested.

Coues, E. 1866. List of the birds of Fort Whipple, Arizona. Proc. Acad. Nat. Sci. Phila. 18:39-100.

"Resident in southern Arizona," individual birds reported at Fort Yuma, September 1865.

Coues, E. 1897. The manuscript journals of Alexander Henry and of David Thompson, 1799-1814. Edited by E. Coues. Francis P. Harper, New York. 1027 pp.

January 1814, two records of condors near Portland, Oregon.

Cowles, R. B. 1958. Starving the condors? Calif. Fish Game 44(2):175-181.

Suggests that fire control has indirectly harmed condors by increasing brush cover, decreasing availability of animal carcasses.

Cowles, R. B. 1967. Fire suppression, faunal changes and condor diets. Pages 217-224 *in* Proceedings of California Tall Timbers Fire Ecology Conference, November 9-10.

Suggests that condors are not getting enough calcium in their diet (small mammals less available as food), so egg production is declining.

Crandall, L. S. 1925. Giant birds of prey. Mentor 13(5):1-12.

Brief popular account of condor included.

Crandall, L. S. 1927. Great birds of prey. N.Y. Zool. Soc. Bull. 30(2):26-47.

Includes two photos of immature condors.

Cruickshank, A. D. 1944. In quest of the condor. Nat. Mag. 37(1):13, 48.

Seeing condors near Fillmore, Ventura County.

Crowe, E. 1957. Men of El Tejon, empire in the Tehachapis. Ward Ritchie Press, Los Angeles. 165 pp.

Pages 101-103, story about capturing a condor.

Curl, A. L. 1958. [Cooper Society meeting notes.] Condor 60(1):72.

D. McLean reports two condors feeding on a dead cow near Mt. Hamilton, Santa Clara County, 15 July 1958.

Daggett, F. S. 1898a. Eagle or vulture? Osprey 2(10):133.

Possible condor near Paso Robles.

Daggett, F. S. 1898b. Capture of a California condor. Osprey 2(10):134.

Immature condor with broken wing found in San Gabriel Canyon, Los Angeles County, 4 March 1898; kept alive, later became museum specimen.

Daggett, F. S. 1901a. Capture of a California condor near Pomona, California. Condor 3(2):48.

Immature condor shot in Los Angeles County, 16 January 1901, brought to Daggett.

Daggett, F. S. 1901b. Summer observations in the southern Sierras. Condor 3(5):117-119.

June 1901, one condor seen near Grapevine, Kern County; local residents reporting seeing "numbers of them" at times.

Daniel, J. W. 1900. A day in Rubio Canyon. Wilson Bull. 32(1):2-4.

One condor seen near Pasadena; no date given.

Daniel, J. W. 1903. National Zoo bird items. Am. Ornithol. 3(7):236-237.
Two condors in National Zoo; photo of immature bird.

Davie, O. 1898. Nests and eggs of North American birds. David McKay, Philadelphia. 509 pp.
Pages 191-194, summary of egg collecting records.

Davis, M. 1946. Morning display of the California condor. Auk 63(1):85.
Describes spread-wing postures of captive condor.

Dawson, W. L. 1923. The birds of California. South Moulton Co., San Diego. 2121 pp.
General account of life history and status; firsthand account of visiting a condor nest.

Dawson, W. L., and J. H. Bowles. 1909. The birds of Washington. Occidental Publishing Co., Seattle. 997 pp.
Condor believed to be a former visitor from the south; no longer seen.

de la Ascension, A. 1928. Father Antonio de la Ascension's account of the voyage of Sebastian Vizcaino. Calif. Hist. Soc. Q. 7(4):295-394.
December 1602, birds that were probably condors seen at Monterey, California; *not* feeding on a whale, as record is often interpreted.

Delaney, J. 1974. Saving the thunderbird. San Jose Mercury-News, California Today Suppl., 15 September:20-21.
Popular status report.

De Lasaux, H. 1954. California condor will soar again. Am. For. 60(3):13, 49.
Popular status report.

De Saussure, R. 1956. Remains of the California condor in Arizona caves. Plateau 29(2):44-45.
Condor bones found in three caves in Grand Canyon area.

De Schauensee, R. M. 1941. Rare and extinct birds in the collection of the Academy of Natural Sciences of Philadelphia. Proc. Acad. Nat. Sci. Phila. 93:281-324.
Four condor specimens.

Devoe, A. 1953. Vanishing giants. American Weekly, 19 July:6-8.
Controversy over San Diego Zoo attempt to capture condors.

Dillard, G. M. 1938. [Letter to the editor.] Calif. Conserv. 3(4):8.
Trip to Sisquoc Falls, September 1889, "20 or 30" condors roosting there.

Dillon, R. 1966. The legend of Grizzly Adams. New York, Coward-McCann, Inc. 223 pp.
May or June 1854, Walker River, Nevada; Adams reportedly shot a condor (may be fictional).

Dixon, J. 1924. California condors breed in captivity. Condor 26(5):192.
Egg laying (none fertile) by condors in National Zoo; bird 12 years old when first egg laid.

Douglas, D. 1829. Observations on the *Vultur Californianus* of Shaw. Vigor's Zool. J. 4(1):328-330.
Observations made in Washington and Oregon as far north as the Canadian border, most common along the lower Columbia River. Famous nonsense about black eggs and nests on ground.

Douglas, D. 1914. Journal kept by David Douglas during his travels in North America, 1823-1827. London, William Wesley and Son. 364 pp.
Condors "plentiful" on Umpqua River, Oregon, 3 October 1823 — nine seen in one flock; winter 1826-1827, lower Columbia River area, many condors seen (two collected), but seldom more than one or two at a time.

Downie, D. 1966. The compleat pilot — try it on quiet wings. Private Pilot Mag. 2(12):21-23, 44.
Condor photographed from a sailplane.

Drury, C. M., ed. 1957. Diary of Titian Ramsay Peale. Los Angeles, Dawson's Book Store. 85 pp.
Condors seen in Umpqua River area, Oregon, 24 October 1841; condors seen near Mt. Shasta and in northern Sacramento Valley, October 1841.

Dunn, H. H. 1905. The California Vulture. Am. Ornithol. 5(12):289-292.
General account; brief account of visiting condor nests with eggs in Orange and Los Angeles counties.

Dunn, H. H. 1907. How I found the nest of the condor. Am. Boy 8(4):127.
Nest visited in Orange County in late April, about 1904; nestling and two adult condors seen.

Dyer, E. I. 1935. Meeting the condor on its own ground. Condor 37(1):5-11.
Put bait out to attract condors, seven (five adults, two immatures) came to bait; also 1933 report of two condors, Santa Clara County.

Edwards, H. A. 1913. California condor. Oologist 30(5):74.
One condor seen at Eagle Rock, Los Angeles County, 14 February 1913.

Eissler, F. 1964. Condors and wilderness. Sierra Club Bull. 49(3):10-12.
Controversy over Sierra Madre Ridge road proposal.

Elliott, C., ed. 1942. Fading trails, the story of endangered American wildlife. MacMillan Co., New York. 279 pp.
Pages 118-126, popular summary of life history and status.

Emerson, W. O. 1887. Ornithological observations in San Diego County. Bull. Calif. Acad. Sci. 2:419-431.
April 1884, one condor seen, Poway Valley.

Evermann, B. W. 1886a. The yellow-billed magpie. Am. Nat. 20(7):607-611.
Condor feeding on dead pig near Santa Paula, 2 April 1881.

Evermann, B. W. 1886b. A list of the birds observed in Ventura County, California. Auk 3(1):86-94, 3(2):179-186.
Condor listed as "resident."

Evermann, B. W. 1886c. Birds observed in Ventura County, California. Pac. Sci. Mon. 1(8):77-89.
Condor "resident."

Fannin, J. 1897. The California vulture in Alberta. Auk 14(1):89.
Two condors reported near Calgary, 10 September 1896; record disputed.

Farquhar, F. P., ed. 1930. Up and down California in 1860-1864, the journal of William H. Brewer. Yale University Press, New Haven. 601 pp.
Condors reported near Monterey in May 1861, and near Pescadero, Monterey County, in July 1861.

Finley, W. L. 1906. Life history of the California condor. Part I. Condor 8(6):135-142.
Detailed observations at Los Angeles County nest site.

Finley, W. L. 1908a. Life history of the California condor. Part II. Condor 10(1):5-10.
Good compilation of distribution, and egg and skin collecting records.

Finley, W. L. 1908b. Life history of the California condor. Part III. Condor 10(2):59-65.
More observations at Los Angeles County nest.

Finley, W. L. 1908c. Home life of the California condor. Century 75(3):370-380.
Nest observations.

Finley, W. L. 1908d. California condor. Sci. Am. 99(1):7-8.
General life history.

Finley, W. L. 1909. General, a pet California condor. Ctry. Life 16(1):35-38.
Observations of a captive bird.

Finley, W. L. 1910. Life history of the California condor. Condor 12(1):5-11.
Behavior of "General," an immature condor, in captivity.

Finley, W. L., and I. Finley. 1915. Condor as a pet. Bird-lore 17(5):413-419.
"General," the condor.

Finley, W. L., and I. Finley. 1926. Passing of the California condor. Nat. Mag. 8(2):95-99.
Popular account of life history and status.

Fisher, A. K. 1893. Report on the ornithology of the Death Valley expedition of 1891. N. Am. Fauna 7:7-158.
Condor "still tolerably common in certain localities west of the Sierra Nevada"; two possible sightings in Owens Valley.

Fisher, H. I. 1939. Pterylosis of the black vulture. Auk 56(4):407-410.
Feather tracts compared to *Gymnogyps* and other cathartids.

Fisher, H. I. 1942. The pterylosis of the Andean condor. Condor 44(1):30-32.
Compared with other cathartids.

Fisher, H. I. 1943. The pterylosis of the king vulture. Condor 45(2):69-73.
Compared with other cathartids.

Fisher, H. I. 1944. The skulls of the cathartid vultures. Condor 46(6):272-296.
Comparisons of cathartid skulls with other falconiform birds; concludes that Pleistocene and Recent California condors represent different species.

Fisher, H. I. 1945a. Flying ability and the anterior intermuscular line on the coracoid. Auk 62(1):125-129.
Cathartid vultures compared with other birds.

Fisher, H. I. 1945b. Locomotion in the fossil vulture *Teratornis.* Am. Midl. Nat. 33(3):725-742.
Compared to *Gymnogyps.*

Fisher, H. I. 1946. Adaptations and comparative anatomy of the locomotor apparatus of New World vultures. Am. Midl. Nat. 35(3):545-727.
Good discussion of flight, use of legs, etc., by *Gymnogyps* and other American vultures.

Fisher, H. I. 1947. The skeletons of recent and fossil *Gymnogyps*. Pac. Sci. 1(4):227-236.
Significance tests from 34 different measurements and ratios "demonstrate conclusively that we are dealing with two distinct forms."

Fisher, W. K. 1904. California vulture in San Mateo Co., California. Condor 6(2):50.
January 1904, one condor seen near Stanford University.

Fleming, J. H. 1924. The California condor in Washington: another version of an old record. Condor 26(3):111-112.
David Douglas collections, 1827.

Flint, P. 1940. Speaking of wings. Los Angeles Times Sunday Magazine, 29 September:7-8.
Aviation engineers make detailed examinations of condor museum specimens; J. R. Pemberton films condors at a carcass.

Fox, W. W. 1973. Condors. Sci. Dig. 74(1):34-38.
Popular compilation.

Fox, W. W. 1974. Will the condor wander yonder? Westways 66(2):56-58, 68, 70.
Popular compilation.

Frazer, J. G. 1935. The golden bough: a study of magic and religion. The MacMillan Co., New York, 752 pp.
Pages 499-501, sacrificial use of condor by California Indians.

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Pages 51-59, description and bibliography.

Friedmann, H., L. Griscom, and R. T. Moore. 1950. Distributional check-list of the birds of Mexico. Pac. Coast Avifauna 29:1-202.
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Two condors presumably killed by eating poisoned sheep carcass, 1890; proposes law to make killing condors, taking condor eggs, or putting out poisoned baits felonies.

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Fry 1926, plus compilation of records for Sequoia National Park and vicinity.

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Summarizes Oregon condor records.

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Courtship compared to *Gymnogyps*.

Gale, N. B., and F. S. Todd. 1968. A note on the California condor *Gymnogyps californianus* at Los Angeles Zoo. Int. Zoo Yearb. 8:213.
Captive immature.

Gallaher, W. 1906. A novel find. Condor 8(2):57.
November 1905, "dried up" condor egg found in Ventura County.

Gambel, W. 1846. Remarks on the birds observed in upper California. Proc. Acad. Nat. Sci. Phila. 3:44-48.
General comments on condor, apparently not firsthand.

Gass, P. 1904. Gass's journal of the Lewis and Clark expedition. Reprint of edition of 1811. A. C. McClurg and Co., Chicago. 298 pp.
Condor records along Columbia River, 1806.

Gedney, P. L. 1900. Nesting of the condor on the slope of the Cuyamacas, San Diego Co., Cal. Condor 2(6):124-126.
Condor egg taken from Boulder Creek area.

Gifford, E. W. 1926. Miwok cults. Univ. Calif. Publ. Am. Archeol. Ethnol. 18(3):391-408.
Condor (moluku) important "bird chief," used in Miwok ceremonies.

Gifford, E. W. 1932. The Northfork Mono. Univ. Calif. Publ. Am. Archeol. Ethnol. 31(2):15-65.
Condor (nuniyot) reputed to carry off sleeping people.

Gifford, E. W. 1955. Central Miwok ceremonies. Univ. Calif. Anthropol. Rec. 14(4):261-318.
Description of moluku dance, celebrating the killing of a condor.

Gifford, E. W., and G. H. Block. 1930. California Indian nights entertainments. Arthur H. Clark Co., Glendale. 323 pp.
Condor a good character in myths of Humboldt County (Wiyot) Indians, a bad character in Madera County (Western Mono) myth.

Gilbert, B. 1967. A close look at wildlife in America. Saturday Evening Post 240(18):32-48.
Condor included in popular account.

Gilman, M. F. 1907. Measuring a condor. Condor 9(4):106-108.
Records of 2 condors shot in San Diego County, 1900-1901; 1888, 14 condors seen in San Bernardino County; two presumed nest sites in San Jacinto Mountain area, Riverside County.

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Humboldt County Indians may have had a name for the condor — yondiyauw = eats whale.

Goldman, E. W. 1951. Biological investigations in Mexico. Smithsonian Institution, Washington, D.C. 476 pp.
July 1905, Sierra San Pedro Martir, Baja California: condors "rather common," saw about a dozen on a burro carcass, collected one.

Gray, G. R. 1844. List of the specimens of birds in the collection of the British Museum. Part I — Accipiters. London. 209 pp.
One condor specimen (the type specimen).

Greene, C., and J. Olsen. 1941. Meet the giant California condor, the world's largest bird. Man to Man 17:38-39, 78-79.
Highly popularized account of condor observations.

Greene, E. R. 1966. A lifetime with the birds: an ornithological logbook. Edwards Bros. Inc., Ann Arbor. 404 pp.
Observations of condors in the Sespe area, 1949-1958.

Greenway, J. C., Jr. 1958. Extinct and vanishing birds of the world. American Committee for International Wildlife Protection, New York. 518 pp.
General summary of life history and status.

Grinnell, J. 1898. Birds of the Pacific slope of Los Angeles County. Pasadena Acad. Sci. Publ. 2. 52 pp.
Condor "tolerably common" and "not by any means becoming extinct."

Grinnell, J. 1905a. Old Fort Tejon. Condor 7(1):9-13.
July 1904, Kern County, saw two condors, others reported them common in the vicinity.

Grinnell, J. 1905b. Summer birds of Mt. Pinos, California. Auk 22(4):378-391.
Late June 1904, saw single condors twice; local residents said condors were common.

Grinnell, J. 1909. Editorial notes and news. Condor 11(3):104.
Immature condor shot at Los Angeles County nest site, shooter fined $50.

Grinnell, J. 1915. A distributional list of the birds of California. Pac. Coast Avifauna 11. 217 pp.
Condor distribution summarized.

Grinnell, J. 1928. A distributional summation of the ornithology of Lower California. Univ. Calif. Publ. Zool. 32(1):1-300.
Condor records in Baja California summarized.

Grinnell, J. 1932a. Type localities of birds described from California. Univ. Calif. Publ. Zool. 38(3):243-324.
Condor type in British Museum, probably collected near Monterey, California, in late 1792 or early 1793.

Grinnell, J. 1932b. Archibald Menzies, first collector of California birds. Condor 34(6):243-252.
Description of condor type specimen.

Grinnell, J., J. Dixon, and J. M. Linsdale. 1930. Vertebrate natural history of a section of northern California through Lassen Peak. University of California Press, Berkeley. 594 pp.
Historical records reviewed, no recent condor reports from area.

Grinnell, J., and A. H. Miller. 1944. The distribution of the birds of California. Pac. Coast Avifauna 27. 608 pp.
Distribution summary.

Grinnell, J., and H. S. Swarth. 1913. An account of the birds and mammals of the San Jacinto area of southern California. Univ. Calif. Publ. Zool. 10(10):197-406.
Condor former resident, no recent records.

Grinnell, J., and M. W. Wythe. 1927. Directory of the bird-life of the San Francisco Bay region. Pac. Coast Avifauna 18. 160 pp.
Summary of condor records; none since 1904.

Groner, D. E. 1956. [Cooper Ornithological Society meeting notes.] Condor 58(1):80.
Five condors seen near Fillmore, Ventura County, 16 October 1955.

Groner, D. E. 1958. [Cooper Ornithological Society meeting notes.] Condor 60(2):143.
At least 17 (possibly 25-30) condors at Mt. Pinos, Ventura County, 24 August 1957.

Gurney, J. H. 1894. Catalogue of the birds of prey with the number of specimens in Norwich Museum. London. 56 pp.
Museum had four skins, one skeleton, one egg on condor. "Lord Walsingham has shot vultures a good bit north of Mendocino (northern California), probably the rare *Pseudogryphus* (*Gymnogyps*) *californianus.*"

Hall, F. W. 1933a. Studies in the history of ornithology in the State of Washington (1792-1932) with special reference to the discovery of new species. Part II, Lewis and Clark. Murrelet 14(3):55-70.
Summarizes condor sightings by Lewis and Clark, Columbia River area, 1806.

Hall, F. W. 1933b. Studies in the history of ornithology in the State of Washington. Part III, David Douglas, Murrelet 15(1):3-19.
Summarizes David Douglas condor records.

Hamilton, A. 1952. Can the condor come back? Sci. Dig. 31(2):27-31.
Popular summary, past and present.

Harris, H. 1928. Robert Ridgway. Condor 30(1):4-118.
Dr. Langley condor flight computations discussed.

Harris, H. 1941. The annals of *Gymnogyps* to 1900. Condor 43(1):3-55.
Excellent summary of early written records of condors.

Harrison, G. 1967. The valley of the condors. Natl. Wildl. 5(6):4-9.
Popular account of trip to Sespe Condor Sanctuary.

Heald, W. F. 1960. Last stand of the California condor. Frontiers 25(2):105-106, 128.
Popular summary.

Heermann, A. L. 1859. Report of explorations and surveys for a railroad route from the Mississippi River to the Pacific Ocean, 1853-56. Vol. 10, Part 4, pages 29-80 *in* Report upon the birds collected on the survey. Beverly Tucker, Washington.
Records for Tejon Valley, Kern County, 1853; two nests presumably seen in the Sierra Nevada, one in San Diego County.

Heizer, R. F., and G. W. Hewes. 1940. Animal ceremonialism in central California in the light of archeology. Am. Anthropol., New Ser. 42(4):587-603.
Bones and feet of condors and other raptors found in Indian burial sites, apparently part of regalia rather than actual burial of birds.

Henshaw, H. W. 1875. Report upon the ornithological collections made in portions of Nevada, Utah, California, Colorado and New Mexico during the years 1871, 1872, 1873 and 1874. Vol. V., Chapter III, pages 133-508 *in* U.S. Geographical Survey west of the 100th Meridian. U.S. Government Printing Office, Washington, D.C.

One condor seen feeding on a dead horse with turkey vultures, Beaver, Utah, 25 November 1872.

Henshaw, H. W. 1876. Report on the ornithology of the portions of California visited during the field season of 1875. Pages 224-278 *in* G. M. Wheeler, Annual report upon the geographical survey west of the 100th Meridian in California, Nevada, Utah, Colorado, Wyoming, New Mexico, Arizona and Montana. U.S. Government Printing Office, Washington, D.C.

Few condors seen; "it seems highly probable that great numbers of these birds" have died from eating strychnine-poisoned carcasses (but no details given).

Henshaw, H. W. 1920. Autobiographical notes. Condor 22(1):3-10.

Four condors seen at Mission San Antonio, Monterey County, 27 September 1884; hunter later collected three specimens for Henshaw.

Hess, C. N. 1930. King condor. Touring Topics 22(8):18-21, 56.

Comprehensive popular article.

Hess, C. N. 1957. Sky sovereign. Westways 49(3):20-21.

Popular account.

Hill, B. M., and I. L. Wiggins. 1948. Ornithological notes from lower California. Condor 50(4):155-161.

Summary of earlier sightings, no condors since 1935.

Hill, N. P. 1944. Sexual dimorphism in the Falconiformes. Auk 61(2):228-234.

Wing, tail, tarsus, and culmen measurements show male and female condors about same size.

Hilton, J. R. 1971. What fate for *Gymnogyps*? Calif. Condor (Society for the Preservation of Birds of Prey) 6(2):1-5.

Popular summary of recent research and management.

Hilton, J. R. 1976. California condor: captive breeding in its future? Raptor Rep. 4(3):15.

Pros and cons of captive propagation discussed.

Hoffman, W. H. 1895. Notes on California condors. Avifauna 1(2):17-19.

Condor egg collection records.

Hoffmann, R. 1930. California condor. Gull 12(10):6.

Recent (no date) sighting of 10 condors (8 adults, 2 immatures) in Sisquoc Falls Area, Santa Barbara County.

Holland, H. 1945. America's largest flyer. Fauna 7(3):86-89.

General account of history and current status.

Holmes, F. H. 1897. A pet condor. Nidiologist 4(6):58-59.
Description and photos of captive immature "Ben Butler."

Hovland, C., and D. Hovland. 1972. America's endangered wildlife. Tower Publications, New York. 182 pp.
Pages 37-42, popular account, some inaccuracies.

Howard, H. 1929. The avifauna of Emeryville shellmound. Univ. Calif. Publ. Zool. 32(2):301-394.
Bones of one condor found.

Howard, H. 1930. A census of the Pleistocene birds of Rancho La Brea from the collections of the Los Angeles Museum. Condor 32(2):81-89.
Pleistocene *Gymnogyps* abundant in the fossil record.

Howard, H. 1938. [Cooper Ornithological Society meeting notes.] Condor 40(3):132.
Hearsay report of condor found dead after feeding on deer carcass; another condor caught in an animal trap.

Howard, H. 1947. A preliminary survey of trends in avian evolution from Pleistocene to recent times. Condor 49(1):10-13.
All Pleistocene condors now considered *G. amplus.*

Howard, H. 1952. The prehistoric avifauna of Smith Creek Cave, Nevada, with a description of a new gigantic raptor. Bull. South. Calif. Acad. Sci. 51(2):50-54.
Five bone fragments tentatively classified as *Gymnogyps.*

Howard, H. 1962a. Bird remains from a prehistoric cave deposit in Grant County, New Mexico. Condor 64(3):241-242.
At least eight individual condors represented, including three very young birds.

Howard, H. 1962b. A comparison of avian assemblages from individual pits at Rancho La Brea, California. Los Ang. Cty. Mus. Contrib. Sci. 58. 24 pp.
Two hundred fifteen *Gymnogyps amplus* specimens, apparently more in older pits than in more recent deposits.

Howard, H. 1971. Quaternary avian remains from Dark Canyon Cave, New Mexico. Condor 73(2):237-240.
Seventeen bones of *Gymnogyps amplus* found; previous identification of condor bones in Shelter Cave (Howard and Miller 1933) in error, bones reassigned to *Breagyps.*

Howard, H. 1974. Postcranial elements of the extinct condor *Breagyps clarki* (Miller). Los Ang. Nat. Hist. Mus., Contrib. Sci. 256:1-24.
Detailed comparison of bones with those of *Gymnogyps* and *Vultur.*

Howard, H., and A. H. Miller. 1933. Bird remains from cave deposits in New Mexico. Condor 35(1):15-18.
Condor bones found in two caves.

Howard, H., and A. H. Miller. 1939. The avifauna associated with human remains at Rancho La Brea, California. Carnegie Inst. Publ. 514:39-48.
Only one condor specimen in pit containing human remains.

Howard, J. and M. Howard. 1967. Condor. Better Camping 8(9):32-35.
Where and how to observe condors.

Howland, S. 1882. Golden eagle's eggs. Ornithol. Oologist 7(17):131.
Notes that J. G. Cooper has condor egg in possession.

Hubbard, F. 1969. 130 man survey team reports 52 condors. Outdoor Calif. 30(1):4-5.
1968 cooperative survey results.

Hubbard, F. 1972. California's condor — winning or losing? Outdoor Calif. 33(6):1.
1972 cooperative survey.

Huey, L. M. 1926. Notes from northwestern Lower California, with the description of an apparently new race of the screech owl. Auk 43(3):347-362.
One condor in Sierra San Pedro Martir, 12 June 1923; one condor in Sierra Juarez, 21 July 1924.

Huey, L. M. 1938. Frank Stephens, pioneer. Condor 40(3):101-110.
November 1908, one condor seen on Mexican border near Pacific Ocean.

Hunter, J. S. 1904. Records from the vicinity of Watsonville, California. Condor 6(1):24-25.
Summer 1903, condors seen several times.

Ingersoll, A. M. 1919. Albert Mills Ingersoll — an autobiography. Condor 21(2):53-57.
Brief mention of condor egg in his possession.

James, G. W. 1906. The wonders of the Colorado Desert. Little, Brown and Co., Boston. 547 pp.
Reports a condor killed, details not clear.

Jenkins, H. O. 1906. A list of birds collected between Monterey and San Simeon in the Coast Range of California. Condor 8(5):122-130.
Eight to ten condors roosting in redwood grove, Villa Creek, Monterey County, 18 July 1905.

Jewett, S. C., W. P. Taylor, W. T. Shaw, and J. W. Aldrich. 1953. Birds of Washington State. University Washington Press, Seattle. 767 pp.
Summarizes Washington records; last record apparently 30 September 1897, one bird near Coulee City.

Johnson, H. T. 1945. California condors in San Luis Obispo County, California. Condor 47(1):38.
Twenty condors feeding on animal carcass, Cholame Flats, 14 June 1944.

Jordan, D. S. 1922. The days of a man. Vol. I. World Book Co., Yonkers on Hudson. 709 pp.
Condors seen and reportedly nesting, 1904-1908, Pinnacles area, San Benito County.

Josephy, A. M. Jr. 1951. Condors don't pay taxes. Blue Book, December: 52-55.
Popular account of establishing Sespe Condor Sanctuary.

Keast, D. N. 1965. The noise environment of the California condor. Bolt, Beranek and Newman, Inc., Los Angeles. 29 pp.
Evaluates noise levels in Sespe Condor Sanctuary in relation to proposed Sespe Water Project.

Kellogg, F. L. 1910. Mallophagan parasites from the California condor. Science 31(784):33-34.

Two species, *Menopon* and *Lipeurus,* removed from one condor specimen.

Kelly, A. 1906. How the condor seeks its food. Outing 47(6):782.

A number of condors (unspecified, but apparently quite a few) attracted to a cow carcass on Tejon Ranch, Kern County.

Kermode, F. 1904. Catalogue of British Columbia birds. Victoria, B.C. 69 pp.

Condor records summarized; concludes it is an accidental visitant.

Kessler, J. 1941. The big three. Cassinia 31:25-33.

1937, two condors seen in Sespe Canyon, Ventura County.

Kofoid, C. A. 1923. An early account of the California condor. Condor 25(1):29-30.

Adolphe Boucard description of condors on whale, San Francisco, 1851 or 1852.

Koford, C. B. 1953a. [Photograph of nestling condor.] Condor 55(3):150.

Koford, C. B. 1953b. The California condor. Natl. Audubon Soc. Res. Rep. 4. 154 pp.

Monographic study of condors, particularly nesting activity.

Kohls, G. M., and H. Hoogstraal. 1960. Observations on the subgenus *Argas* (Ixodoidea, Argasidae, *Argas*). 2 *A. Cooleyi,* new species, from western North American birds. Annals Entomol. Soc. Am. 53(5):625-631.

Tick recorded three times in vicinity of condor nest.

Kroeber, A. L. 1906-07. Indian myths of south central California. Univ. Calif. Publ. Am. Archeol. Ethnol. 4(4):167-250.

Condor (called "wech") portrayed as bad influence in three Yokut myths.

Kroeber, A. L. 1908. A mission record of the California Indians. Univ. Calif. Publ. Am. Archeol. Ethnol. 8(1):1-127.

Luiseno Indian name for condor is "Yungavaiwot"; condor not as important in ceremonies as is eagle.

Kroeber, A. L. 1925. Handbook of the Indians of California. Smithson. Inst. Bur. Am. Ethnol. Bull., 78. 995 pp.

Condor described in legends and ceremonies of Indian tribes throughout California.

Kroeber, A. L. 1929. The Valley Nisenan. Univ. Calif. Publ. Am. Archeol. Ethnol. 24(4):253-290.

Sacramento Valley Indians included condor (mo'lok') in myth about origin of fire.

Kushlan, J. A. 1973. Spread-wing posturing in cathartid vultures. Auk 90(4):889-890.

Comparative behavior of vultures.

Larson, G. C. 1975. Westerlies: Sanctuary. Flying 96(5):80-81.

Popular account of aircraft restrictions in condor nesting areas.

Law, L. B. 1934a. [Meeting notes, Cooper Ornithological Club.] Condor 36(1):48.

S. Peyton reports two probable nestlings in Sespe Area.

Law, L. B. 1934b. [Meeting notes, Cooper Ornithological Club.] Condor 36(4):184.
Six condors seen, Sespe Canyon, 22 April 1934.

Law, L. B. 1935. [Meeting notes, Cooper Ornithological Club.] Condor 37(4):221.
Clam shells in 1934 condor nest; two condors seen, Gaviota Pass, Santa Barbara County.

Lawrence, R. E. 1893. *Pseudogryphus californianus.* Auk 10(3):300-301.
Data on three condor specimens.

Lawrence, R. E. 1894. The California vulture in the San Gabriel Range, California. Auk 11(1):76-77.
Condor shot at, but apparently not killed.

Laycock, G. 1968. The rancher and the condors. Farm Q. 23(3):74-75,86,90,92.
Popular status report.

Leach, F. A. 1929. A turkey buzzard roost. Condor 31(1):21-23.
Napa County, California: condors frequently seen 1857-1860, seldom seen after 1860.

Levy, C. 1965. The California condor. Calif. Monthly 75(3):44-45.
Popular summary of Miller et al. 1965.

Ligon, J. D. 1967. Relationship of the Cathartid vultures. Occas. Pap. Mus. Zool., Univ. Mich. 651:1-26.
Concludes that Cathartidae "are not at all closely related to the remainder of the Falconiformes, that they share a great many features with the storks, Cinconiidae."

Linsdale, J. M. 1936. The birds of Nevada. Pac. Coast Avifauna 23. 145 pp.
One post-Pleistocene record for the State.

Linsdale, J. M. 1951. A list of the birds of Nevada. Condor 53(5):228-249.
One post-Pleistocene record for the State.

Linton, C. B. 1908. Notes from Buena Vista Lake, May 20 to June 16, 1907. Condor 10(5):196-198.
"Reported breeding in mountains near lake."

Locke, L. N., G. E. Bagley, D. N. Frickie, and L. T. Young. 1969. Lead poisoning and aspergillosis in an Andean condor. J. Am. Vet. Med. Assoc. 155(7):1052-1056.
Lead shot ingested with food; suggest California condor may be susceptible to same.

Loeb, E. M. 1926. Pomo folkways. Univ. Calif. Publ. Am. Archeol. Ethnol. 19(2):149-404.
Pages 384-385, Pomo condor dance described.

Lofberg, L. M. 1936. Twenty condors dine together. Condor 38(4):177.
Twenty condors on sheep carcass east of Bakersfield, Kern County, 25 April 1936; winter 1936, "good authority" reports six condors in Breckenridge Mountain area, Kern County.

Lovejoy, T. 1976. We must decide which species will go forever. Smithsonian 7(4):52-59.

Using a trip to see condors as a springboard, discusses the problems of impending extinctions and concludes (unhappily) that we may have to set up a system of deciding what to save and what not to save.

Lucas, F. A. 1891. Animals recently extinct or threatened with extermination, as represented in the collections of the United States National Museum. Pages 609-649 *in* Annual Report of the U.S. National Museum, 1889.

Doubts that killing condors for their quills was an important mortality factor.

Lume, C. R. 1938. Stalking America's mightiest bird. Travel Mag. 70(3):30-31, 52-53.

Dramatic and exaggerated story of collecting a condor egg in Baja California.

Lyon, M. W., Jr. 1918. [Report of the Secretary. Biological Society of Washington, 20 October 1917.] J. Wash. Acad. Sci. 8(1):25-28.

Fall 1879, sight record of two condors feeding on sheep carcass near Boise, Idaho.

MacDonald, R. 1964. A death road for the condor. Sports Illus. 20(14):86-89.

Sierra Madre Ridge Road proposal, Santa Barbara County.

Macoun, J., and J. M. Macoun. 1909. Catalogue of Canadian birds. Government Printing Office, Ottawa. 761 pp.

Several pre-1893 British Columbia records; refutes Alberta sighting (Fannin 1897).

Mailliard, J., and J. W. Mailliard. 1901. Birds recorded at Paicines, San Benito Co., California. Condor 3(5):120-127.

Formerly abundant, now rarely seen.

Mallette, R. D. 1970. Operational management plan for California condor. California Department of Fish and Game, Sacramento. 58 pp.

Management and research guidelines.

Mallette, R. D. 1971. Results of California condor baiting effort, 1967-1969. Calif. Dep. Fish Game, Wildl. Manage. Branch Adm. Rep. 71-76. 7 pp.

Short-term baiting programs have limited effectiveness.

Mallette, R. D., and J. C. Borneman. 1966. First cooperative survey of the California condor. Calif. Fish Game 52(3):185-203.

Thirty-eight condors estimated seen.

Mallette, R. D., J. C. Borneman, F. C. Sibley, and R. S. Dalen. 1967. Second cooperative survey of the California condor. Calif. Fish Game 53(3):132-145.

Mallette, R. D., F. C. Sibley, W. D. Carrier, and J. C. Borneman. 1970. California condor surveys, 1969. Calif. Fish Game 56(3):199-202.

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Summary of techniques and results.

Mallette, R. D., S. R. Wilbur, W. D. Carrier, and J. C. Borneman. 1972. California condor survey, 1970. Calif. Fish Game 58(1):67-68.
Twenty-eight condors estimated seen.

Mallette, R. D., S. R. Wilbur, W. D. Carrier, and J. C. Borneman. 1973. California condor survey, 1972. Calif. Fish Game 59(4):317-318.
Thirty-six condors estimated seen.

Mariana, N., Jr. 1968. Valley of the condors. Ranger Rick's Nat. Mag. 2(2):15-19.
Children's account of condor watching trip.

May, J. 1972. Giant condor of California. Creative Educational Society, Inc., Mankato. 37 pp.
Children's account, well done.

May, R. H. 1941. A condor in the San Jacinto Mountains, California. Condor 43(4):199.
Possible sighting of a condor, 15 January 1941.

McClure, H. E. 1950. Condors. News from the bird-banders 25(1):14.
March 1949, up to 25 condors seen regularly east of Bakersfield, Kern County, California.

McCoy, J. J. 1963. The fossil avifauna of Itchtucknee River, Florida. Auk 80(3):335-351.
One bone of *Gymnogyps amplus.*

McGregor, R. C. 1899. Some summer birds of Palomar Mountains, from the notes of J. Maurice Hatch. Condor 1(4):67-68.
June 1897, San Diego County, four condors seen, reputedly breeding in area.

McGregor, R. C. 1901. A list of the land birds of Santa Cruz County, California. Pac. Coast Avifauna 2. 22 pp.
Apparently common in county, breeding in mountains north of Santa Cruz prior to 1900.

McLain, R. B. 1898. The California vulture in Santa Barbara County, California. Auk 15(2):185.
February 1898, condor collected at Lompoc.

McMillan, I. 1953. Condors, politics and game management. Central California Sportsman, reprint from December issue. 3 pp.
San Diego Zoo condor trapping controversy.

McMillan, I. 1965a. An objection to feeding California condors. Defenders of Wildl. News 40(2):45-46.
Extra food not needed, unnatural to provide it.

McMillan, I. 1965b. Shall we save the condor or build another dam? Defenders Wildl. News 40(4):39-40.
Against Sespe Water Project.

McMillan, I. 1966. Poisoned condors. Defenders Wildl. News 41(2):115-116.
Condors possibly poisoned by animal-control projects.

McMillan, I. 1967. Game management vs. condor preservation. Defenders Wildl. News 42(4):365-369.
Criticism of current condor management.

McMillan, I. 1968. Man and the California condor. Dutton and Co., New York. 191 pp.
Popular treatment of condor history and management.

McMillan, I. 1970. Botching the condor program. Defenders Wildl. News 45(1):95-98.
Criticism of recent research and management.

McMillan, I. 1971. The 1971 condor survey — a return to soundness. Defenders Wildl. News 46(4):386.
Comments on annual survey.

McMillan, I. 1975. Man and the condor. West. Tanager 42(2):1-2.
General comments on the condor and its preservation.

Meadows, C. 1933. California condor in San Diego County. Condor 35(6):234.
Two condors seen near Mt. Palomar, 3 August 1933.

Merriam, C. H. 1910. The dawn of the world. Arthur Clark Co., Cleveland. 273 pp.
Condor an important mythological character for the California Miwok Indians.

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BIRDS OF THE ST. CROIX RIVER VALLEY: MINNESOTA AND WISCONSIN

by

Craig A. Faanes

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Dedicated to
Samuel D. Robbins, Jr.
Ornithologist and Friend

Birds of the St. Croix River Valley: Minnesota and Wisconsin

by

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Abstract

The St. Croix River Valley encompasses nearly 11,550 km^2 in east-central Minnesota and northwestern Wisconsin. A wide range of habitats are available for birds including upland oak, lowland deciduous, maple-basswood, lowland and upland coniferous forests, natural basin wetlands, and grasslands. Situated in the north-central region of the United States, the valley is a biological "crossroads" for many species. Because of the mixed affinities of plant communities, the valley includes the northern and southern range limits for a number of species. Also, because the valley lies near the forest-prairie transition zone, many typical western breeding species (e.g. pintail, western meadowlark, yellow-headed blackbird) breed in proximity to typical eastern species such as tufted titmouse, eastern meadowlark, and cardinal.

From 1966 to 1980, I conducted extensive surveys of avian distribution and abundance in the St. Croix River Valley. I have supplemented the results of these surveys with published and unpublished observations contributed by many ornithologists. These additional data include compilations from Christmas Bird Counts sponsored by the National Audubon Society and from the Breeding Bird Survey coordinated by the U.S. Fish and Wildlife Service. Three hundred fourteen species have been recorded in the study area; data are presented on the migration period, nesting season distribution, winter distribution, relative abundance, and habitat use of each species.

Recognizing the uniqueness of the area, and its importance not only to wildlife but also to man, the U.S. Congress designated the St. Croix a National Scenic Riverway. This action provided a considerable degree of protection to lands along and directly adjacent to the river. Unfortunately, no similar legal measure exists to protect lands away from the river. With the exception of the northern quarter of the St. Croix River Valley, agricultural interests have made significant inroads into the habitat base. The continuing expansion of the nearby Minneapolis-St. Paul metropolitan region has degraded or destroyed many woodlots, upland fields, and wetlands. In numerous instances, degradation of natural habitats has influenced the abundance and distribution of bird species. Because of these changes, both the Federal government and State Departments of Natural Resources have listed several species in various categories based on their current status. In the St. Croix River Valley, seven species are endangered, eight are threatened, and 29 are watch or priority status in either or both states. Data presented in this report are of value to land managers, land use specialists, and ornithologists, in assessing current and projected habitat alterations on the avifauna of this valley.

The St. Croix River bisects a large region of western Wisconsin and east central Minnesota that exhibits a wide range of habitat types. This region supports not only birds, but many mammals, fishes, reptiles and amphibians, and several thousand species of vascular and nonvascular plants. The river itself is relatively clean through most of its course, and its natural flow is interrupted by only two small dams.

Because the river lies within a 1-day drive of nearly 10 million people (Waters 1977), use of the area for recreational purposes is extremely heavy. Recreational pursuits include sunbathing, boating, and wild river kayaking in the summer, and ice fishing and cross-country skiing in the winter. The large number of unique and highly fragile habitats that exist there may never be compatible with the uses and abuses of the land that go with expanding human populations.

Through the efforts of a number of citizens concerned with the quality of their environment and the foresightedness of several local, State, and Federal legislators, a portion of the upper St. Croix River Valley (hereafter termed "the Valley") was established as a National Wild and Scenic River. Through establishment of the National Wild and Scenic Rivers Act (P.L. 90:542), the ground rules were established to preserve free-flowing streams that have "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, and other similar values." Any person who has spent time along a stretch of the St. Croix would have to agree that this river meets or exceeds all the criteria that the Act established.

The history of this magnificent valley is cloaked with the adventures of lumber barons, trappers and hunters, commercial fishermen, and many others. During the days of the early voyageurs, the river served as a vital link between the Great Lakes and the growing Minneapolis–St. Paul area. Excellent descriptions of the colorful history of the Valley are provided by Link (1977) and Waters (1977).

Although the Scenic River Act provides considerable protection for the lands and resources directly adjacent to the river, there is no comparable legal measure to protect lands not bordering the river. Several man-influenced impacts are escalating in the Valley and provide a continual threat to remaining resources. Two influences providing the greatest threat to the natural resources of the Valley are urban expansion and agricultural production. First, the continual, almost unabated spread of urban development has already had a profound impact on existing habitats. Second, agriculture has had a growing impact on bird life in the Valley. Lands producing row crops, small grains, and hay in St. Croix County in 1967 totaled 75,910 ha. This acreage increased 17.4% to 88,057 ha by 1977 (U.S. Department of Agriculture, personal communication). The total hectarage of lands in agricultural production (row crops and hay) made up 16 and 18.8% of the Valley in 1967 and 1977, respectively. These examples suggest the magnitude of the impact that agriculture has had upon wildlife resources in the past two decades.

It can be argued that the agricultural hectarages cited above represent changes in cropping practices rather than actual increases in the hectarage of wildlife habitat converted to agricultural production. However, increased technology and the growth of agribusiness have resulted in a shift to fencerow to fencerow farming with serious impacts on many upland habitats.

Wetland habitats have also been significantly reduced. Peterson (1978) showed that over 27% of the seasonal wetlands (Type III of Shaw and Fredine 1956) in St. Croix County were drained between 1958 and 1977.

The objective of this report is to provide, in condensed form, an account of the 314 bird species that have been recorded in the Valley.

Climate

The Valley has a temperate, continental climate that is characterized by extreme seasonal variability. Mean monthly air temperatures are –12 to -9°C in January and 20 to 22°C in July. The average growing season ranges from 100 days in the north (Burnett and Pine counties) to over 120 days in the south (St. Croix and Washington counties). The ground is frozen usually from late November through mid-April and frost depths range from 66 to 86 cm.

Mean annual precipitation is 74.4 cm (Young and Hindall 1973). The range in yearly precipitation is about 71.1 cm at St. Croix Beach, Washington County, to nearly 78.7 cm at Grantsburg, Burnett County (Lindholm et al. 1974). Periods of prolonged drought are highly infrequent. February is usually the driest month (< 2.5 cm) and June the wettest (12.2 cm). Annual evapotranspiration from the St. Croix watershed is 59.4 cm (Lindholm et al. 1974). During July and August, when temperatures are highest and plant moisture demands are greatest, evapotranspiration often exceeds precipitation.

Geology

Interpretations of the interrelation of birds and other wildlife with their environment require an understanding of the geology and soils of an area. The St. Croix River Valley is an area rich in geologic history. Sediments and rock formations throughout the Valley range in geologic age from the 1-billion-year-old Precambrian lava flows at Interstate Park to very recent sediment deposition at the mouth of the Kinnickinnic River.

Bedrock in the upper portion of the Valley consists primarily of Precambrian igneous lava flows, shales, sandstones, and igneous and metamorphic crystalline formations. Bedrock of the lower portions of the Valley consists of marine sandstones, shales, and limestones that were deposited during the Cambrian and Ordovician periods. Outcroppings southward through the Valley indicate that bedrock formations are progressively younger.

Glacial deposits consist mainly of undifferentiated till that was deposited as the last glacier melted about 10,000 years ago. This glacial action was very important in forming the current features of the landscape. Especially important and characteristic among these glacial deposits are the extensive sandy soils associated with the bed of Glacial Lake Grantsburg in Burnett and Pine counties, and the numerous prairie pothole-type wetlands that occur in Polk, St. Croix, and Washington counties.

One important result of past glacial activity in the St. Croix River Valley is the highly productive soils that formed on the glacial outwash. Through the combined action of climate, vegetation, and proper acidity of these gl cial deposits, soils developed that are very important for agricultural pr duction. Productivity of all soils in the Valley is, of course, not equal. Sc conditions range from the sandy, acidic beach-derived soils associated wit Glacial Lake Grantsburg, to the deep, rich loams and silt loam prairie soi of the lower Valley. Productivity of these soils for wildlife appears to corr late nicely. For example, the acidic soils of Glacial Lake Grantsburg ar usually associated with relatively sterile Jack Pine Barren forest which sup ports limited wildlife populations. On the other extreme, the deep, ric prairie soils of the southern regions produce exceptional agricultural crop and also support large and highly diverse wildlife populations.

Physiography and Land Use

The diverse physiographic and topographic features of the Valley result from at least four different glacial epochs that extended from 1 million to 10,000 years ago. The St. Croix River itself is an important component of past and present physiographic changes. The gradient of the river averages 102 cm per km across its entire course, ranging from nearly zero on Lake St. Croix to 4.3 m per km at the Kettle River Rapids, Pine County (Young and Hindall 1973). Altitude of the land surface ranges from about 207 m above sea level at Prescott to about 518 m near Cable at the upper end of the Namekagon River. The interior of the Valley has a general slope ranging from 427 m in the north to about 305 m in the south.

During the last glacial period the St. Croix served as a major drainage for glacial melt waters. Martin (1932) reported that the post-glacial course of the river contained the Apple River Valley in western Wisconsin. In preglacial times, the major course of the river was farther west in Minnesota. In addition to carrying melt waters from the glacier, the St. Croix carried overflow waters from large glacial lakes that occurred in the Lake Superior basin. One outlet was the valley at Solon Springs which is now occupied by St. Croix Lake, the headwaters of the river (Young and Hindall 1973).

Topography of the Valley includes flat-topped, steep-sided sedimentary hills adjacent to the river, and narrow stream valleys in the extreme lower reaches. The remainder of the Valley is composed primarily of broad, flat glacial outwash plains and kettle and knob topography associated with terminal and end moraines.

Lakes and marshes are abundant in the northern half of the Valley where surface drainage systems are poorly developed. One unique drainage system in southern Pine County is separated from all other watersheds in the region by a zone of elevated igneous bedrock. Marshes and streams in this region are characterized by low alkalinity and a deep brownish stained color (Waters 1977). In the southern reaches of the Valley, alkalinity and vegetation of lakes and marshes become progressively greater owing primarily to limestone and sandstone bedrock.

The entire St. Croix watershed encompasses about 11,550 km² (1.7 million ha). The river drains about 7,233 km² in Wisconsin and 4,317 km² in Minnesota (Lindholm et al. 1974). Included in the watershed are all or part of

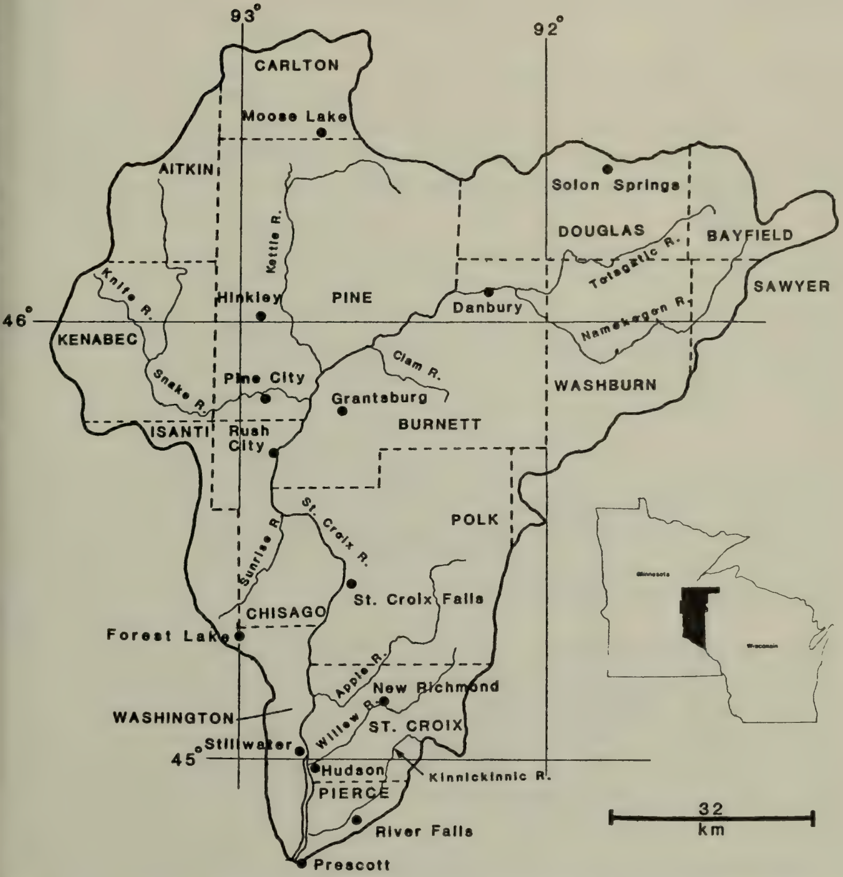


Fig. 1. The St. Croix River watershed, including Minnesota and Wisconsin, encompasses nearly 11,550 km².

18 counties, 9 in each State (Fig. 1). There are eight major streams or watersheds that are tributary to the St. Croix, including the Snake and Kettle rivers, and Pine County streams in Minnesota (Waters 1977), and the Namekagon, Clam, Apple, Willow, and Kinnickinnic rivers in Wisconsin.

Related to the tremendous amount of diversity and variability in the topography and geology of the St. Croix River Valley, various geographers and plant ecologists have developed systems for classifying landforms and major vegetative communities (Fig. 2). These systems have provided divisions that are important in understanding the interrelation of bird distribution with vegetation and geomorphic features. Two separate systems have been developed, one for each State. Both systems have considerable merit considering the foundation upon which they were based. Unfortunately, these separate systems make interpretation of bird distribution awkward when considering the two States. Following is a brief overview of these

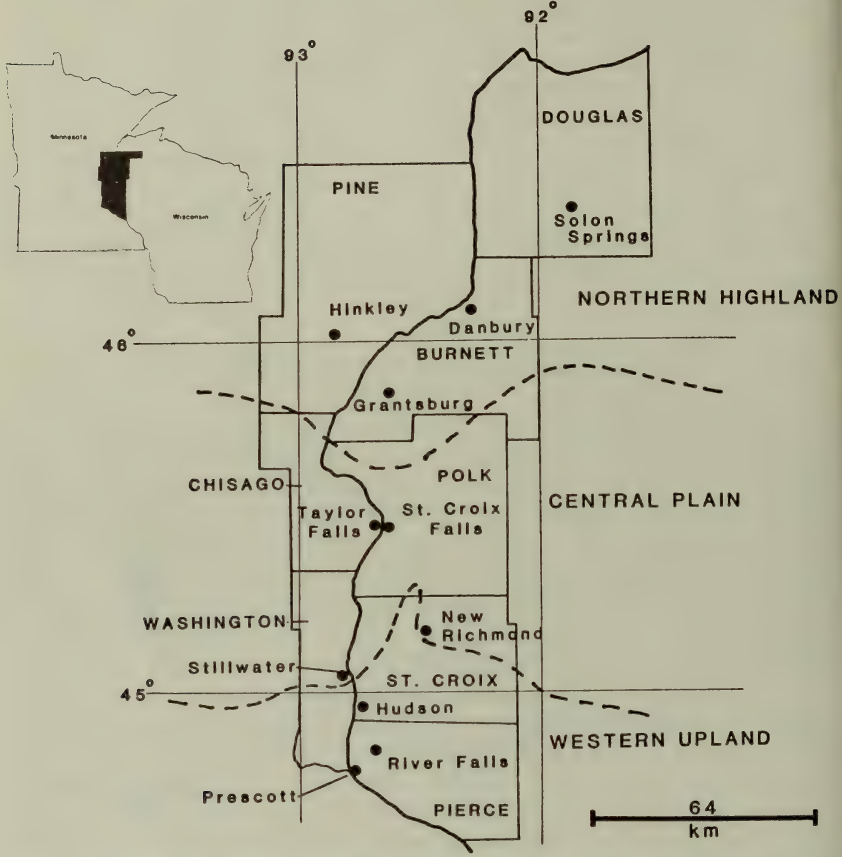


Fig. 2. Major physiographic regions of the St. Croix River Valley.

major divisions by State and the reasons for the combining of systems that I had to consider for interpretation.

The most usable division system for Minnesota was developed by Kratz and Jensen (1977). They developed a system based on both major vegetational and geomorphic provinces and included 17 distinct Ecological–Geomorphic divisions. Four of these divisions are included in the Minnesota counties. A brief description of each follows.

Southern Oak Barrens Section.—This section includes a large region of southeastern Minnesota generally referred to as the Driftless Area, which was not covered by ice during glacial periods. In the Valley, about 80% of Washington County is included in this section. Topography is characterized by highly dissected limestone and sandstone hills adjacent to the St. Croix River. Away from the river, large expanses of glacial outwash and kettle and knob topography predominate. Vegetation consists of a transition between prairie and deciduous forests. Originally, oak barrens and savannah occurred throughout this area.

Mississippi River Sand Plains Section.—This section includes a small portion of northwestern Washington and southwestern Chisago counties where topography is characteristic of glacial outwash plains—including broad, flat areas with occasional wetland basins interspersed. Original vegetation of the sand outwash soils was primarily oak forest with scattered prairie openings and wet prairie in depressions.

Grantsburg Section.—This section includes most of Chisago County and a small part of southern Pine County. Topography is characterized by flat to gently rolling glacial sediments that are frequently dissected by streams. The Grantsburg section includes the bed of Glacial Lake Grantsburg, which extended eastward into Burnett County, Wisconsin. Vegetation originally included Jack Pine Barrens and scattered oak openings. Currently, much of the land is in agricultural production.

Mille Lacs Section.—This section includes most of southern and all of northern Pine County. Topography is characterized by glacial scoured bedrock and glacial till that provide a kettle and knob topography. Forest-bordered lakes are numerous throughout this section. Vegetation is characterized by mixed northern hardwood and coniferous stands with conifer bogs interspersed throughout.

The classification system used in Wisconsin (Martin 1932) is based primarily on physiographic features and bedrock geology, regardless of vegetation. However, the influence of physiography on vegetation is well demonstrated in Wisconsin because the regions that occur in the Valley each support entirely different vegetative communities. Martin considered five distinct physiographic provinces in Wisconsin and the Valley is included in three.

Western Upland.—This region in the Valley is the northern extension of the Driftless Area, a part of Wisconsin, Minnesota, and Illinois that was not covered by glacial ice. Included in the Western Upland are the highly dissected stream valleys adjacent to the St. Croix River and the broad and gently rolling glacial outwash plain of central St. Croix County. Original vegetation included Southern Oak Forest in the dissected area and Tall Grass Prairie associated with the outwash plain. At present, much of the Western Upland is in agricultural production. Portions of central St. Croix, southern Polk, and central Washington counties are dotted with numerous natural basin wetlands.

Central Plain.—This region includes northern St. Croix, southern Burnett, and most of Polk counties. Topography of the Central Plain is also characterized by broad glacial outwash plains lying over Cambrian sandstone in the southern regions. Extensive areas of kettle and knob topography associated with end moraines occur in the north. Numerous lakes and bogs are associated with this topography. Vegetation consists of a mixture of southern oak forest, prairie and northern mixed hardwood, and coniferous forest.

Northern Highland.—This region, which includes northern Burnett and southern Douglas counties, has topography characteristic of morainal deposits and includes numerous high, rounded hills composed of more resistant bedrock. Geology of this region is primarily highly resistant Precambrian igneous rock, quite unlike southern regions of the Valley. Original vegetation of the Northern Highland was composed almost exclusively of pine forest and coniferous bogs. Presently, the pine forest exists only as scattered remnants interspersed throughout extensive mixed second growth deciduous and coniferous forest. Large lakes and extensive bogs are characteristic of the Northern Highland.

This brief discussion of the major physiographic regions of the St. Croix River Valley points out both similarities and differences between the systems developed for each State. For the sake of convenience and clarity in describing bird occurrence and distribution, I have combined both systems. Thus, throughout this report reference to the Western Upland will include the Wisconsin areas outlined in Martin (1932) and the Southern Oak Barrens region of Minnesota described by Kratz and Jensen (1977). The Central Plain will include the Wisconsin areas outlined and those areas of Chisago and Washington counties included in the Mississippi River Sand Plains and the Grantsburg Section. Reference to the Northern Highland will include the Wisconsin areas and the Mille Lacs Section in Pine County. These agree closely with the physiographic regions used by the U.S. Fish and Wildlife Service's Breeding Bird Survey (BBS; Bystrak 1979).

Habitats and Bird Distribution

Within the Valley, a wide range of vegetational communities are available to birds: deciduous and coniferous forest, wetlands, agricultural lands, and urban–residential areas. Original vegetation of the Valley as described by Curtis (1959) and Marschner (1930) included Tall Grass Prairie and Oak Savannah in the Western Upland, Southern Hardwood Forest (primarily oak) and Tall Grass Prairie in the Central Plain, and mixed Coniferous–Deciduous Forest association in the Northern Highland (Fig. 3). Much of the bed of Glacial Lake Grantsburg was composed of relatively sterile jack pine and oak forest. (Scientific names of plants are given in Appendix A.)

Man's presence has had a profound impact on the composition, distribution, and extent of these major communities. The Tall Grass Prairie which may have lapped at the shoulders of early settlers is now field and pastures. The prairie is now confined to railroad rights-of-way and small odd corners that would not accommodate a plow. The majestic white pine forest that once blanketed most of the northern regions has been reduced to scattered remnants.

Habitat changes that adversely affect some bird species often encourage expansion of other species. The clearing of forests of northern white pine has allowed a second growth deciduous disclimax habitat type to develop. Land clearing for agriculture was very important to the advance of the greater prairie chicken (scientific names of birds are given in the species accounts) in this region. Early accounts make vivid reference to the large number of greater prairie chickens that occurred after moderate agricultural expansion. However, the rapacious clearing that accompanied intensified agricul-

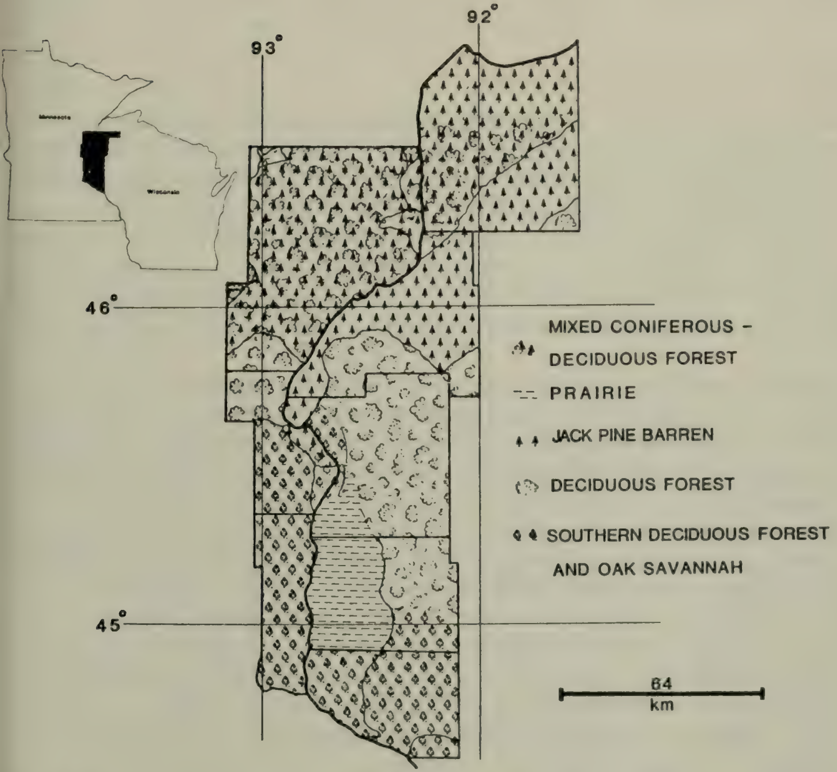

92°
93°
46°
45°
MIXED CONIFEROUS – DECIDUOUS FOREST
PRAIRIE
JACK PINE BARREN
DECIDUOUS FOREST
SOUTHERN DECIDUOUS FOREST AND OAK SAVANNAH
64 km

Fig. 3. Major vegetative communities of the St. Croix River Valley, adapted from Curtis (1959) and Marschner (1930).

tural production also caused the demise of the greater prairie chicken as a natural breeding bird.

An important environmental characteristic that affects bird occurrence and distribution is described by Curtis (1959) as the "Tension Zone." Based on a combination of environmental factors including soil type, annual precipitation, temperature, and geology, this zone of vegetational range extremes has a profound effect on the distribution of many bird species in the Valley. Essentially, this zone is the north–south limit area for many boreal forest and oak forest forbs, shrubs and trees. This contact zone was shown by Beimborn (1969) as important to the distribution of at least 14 bird species in Wisconsin. Robbins (1974*b*) demonstrated the influence of the Tension Zone on the breeding range limits of the alder and willow flycatchers.

Nineteen distinct habitat categories have been identified. Each is presented here in terms of size, distribution, floral characteristics, and characteristic breeding birds. Breeding bird species that apparently reach their greatest density in a specific habitat are marked with an asterisk. Habitat use by migrants will be considered individually with each species account.

Deciduous Forest Communities

Northern Hardwood Forest

This floristic community extends throughout the Northern Highland and much of the Central Plain north of St. Croix Falls (Polk and Chisago counties). Characterized by a mixture of coniferous and deciduous tree types, the Northern Hardwood Forest occurs on a wide range of topographic sites and on many soil types. Mesic sites support white birch, sugar maple, hemlock, basswood, and red oak. Important coniferous species of this habitat are red pine, white pine, and to a limited extent jack pine. Depending on the extent of early successional stages this is generally a climax or near-climax community.

Prevalent within the shrub layer and among ground layer species are beaked hazel, bracken fern, wood anemone, wild sarsaparilla, big-leaf aster, blue bead lily, northern bedstraw, ground pine, Canada mayflower, bishop's cap, Solomon's seal, twisted stalk, starflower, downy yellow violet, rice grass, and Pennsylvania sedge.

Characteristic breeding birds include broad-winged Hawk*, ruffed grouse*, great horned owl, barred owl, black-billed cuckoo*, common flicker, yellow-bellied sapsucker*, hairy woodpecker*, downy woodpecker, great crested flycatcher, least flycatcher*, eastern wood pewee*, blue jay, northern raven, black-capped chickadee, white-breasted nuthatch, American robin, wood thrush, veery*, solitary vireo, red-eyed vireo*, black-and-white warbler, chestnut-sided warbler, ovenbird*, American redstart, northern oriole, scarlet tanager, rose-breasted grosbeak*, and white-throated sparrow.

Lowland Deciduous Forest

This rich deciduous community occurs primarily along the floodplains of larger streams and rivers adjacent to the St. Croix in the Western Upland and Central Plain. The abundant soil moisture from river flooding and high water table is a principal microclimatic feature of this community. Because of its southern plant affinity, Lowland Deciduous Forest attracts some typically southern breeding bird species that occur in no other habitat type. Major tree species characteristic of this community are silver maple, American elm, green ash, red oak, basswood, and cottonwood.

Prevalent species in the shrub layer are black willow, box-elder, and gray dogwood. Depending on the amount of disturbance by grazing cattle, tartarian honeysuckle and prickly ash approach dominance in the shrub layer. Important among ground layer species are jack-in-the-pulpit, toothwort, Virginia waterleaf, wood nettle, poison ivy, germander, hedge nettle, jewelweed, and skunk cabbage.

Characteristic breeding bird species of the Lowland Deciduous Forest include great blue heron*, wood duck*, red-shouldered hawk*, yellow-billed cuckoo, screech owl*, barred owl*, pileated woodpecker*, red-bellied woodpecker*, downy woodpecker, eastern wood pewee, tufted titmouse*, white-breasted nuthatch*, blue-gray gnatcatcher*, yellow-throated vireo*, warbling vireo*, blue-winged warbler*, yellow warbler, cerulean warbler*, Louisiana waterthrush*, northern oriole*, scarlet tanager*, and rose-breasted grosbeak.

Southern Deciduous Forest

This habitat type includes a closed-canopy upland community that is generally restricted to the region south of the Tension Zone in the Western Upland and Central Plain. Southern Deciduous Forest occurs almost exclusively on dry, well-drained upland sites. Before settlement of this region, Southern Deciduous Forest existed as part of an oak forest intermixed with prairie giving the area aspects of a savannah. Currently, stands of Southern Deciduous Forest are primarily restricted to bluff tops and edges adjacent to the St. Croix River and in scattered farm woodlots, which are usually heavily grazed.

Important component trees in this community include red oak, white oak, Hill's oak, and bur oak. In more mesic sites, large-toothed aspen, sugar maple, basswood, and white ash become important. Shrubs indicative of this community include black cherry, common elder, gray dogwood, and hazelnut. Prevalent ground layer vegetation includes dogbane, wild sarsaparilla, rattlesnake fern, tick trefoil, Virginia strawberry, northern bedstraw, wild cranesbill, Jacob's ladder, sweet cicely, wild lettuce, false Solomon's seal, Solomon's seal, wild leek, blue cohosh, goosegrass, bloodroot, large-flowered trillium, and Pennsylvania sedge.

Very few breeding bird species are restricted to or reach their greatest density in the Southern Deciduous Forest in the Valley. Principal breeding species include Cooper's hawk, red-tailed hawk, ruffed grouse, great horned owl, whip-poor-will, common flicker, red-headed woodpecker*, hairy woodpecker, great crested flycatcher, eastern wood pewee, blue jay, common crow, black-capped chickadee, white-breasted nuthatch, house wren, brown thrasher*, American robin, yellow-throated vireo, ovenbird, American redstart, scarlet tanager, rose-breasted grosbeak, indigo bunting, rufous-sided towhee, vesper sparrow (in openings), and field sparrow (in openings).

Deciduous Clear Cuts

A major principle of wildlife management is the provision of a multitude of habitats in various successional stages. Suppression of wildfires and the tremendous reduction of logging that occurred after settlement of the Valley were responsible for allowing many upland sites to return to near climax conditions. Northern Hardwood Forest, dominated primarily by sugar maple and basswood, rapidly becomes prevalent in northern forests that are not managed. Although the mature hardwood forest is a primary habitat for several breeding birds, the lack of early successional stages creates a situation that is relatively unattractive to a number of other species.

Within the last 15 years, foresters and wildlife managers have taken steps to retard succession in several upland forest types. These management practices have been highly successful in providing a variety of successional stage forests and several age classes. Providing a variety of age classes has produced significant beneficial effects for many woodland breeding birds. The primary methods used to accomplish these practices are clear-cutting and selective cutting.

In general, these practices have been accomplished on upland sites in the northern areas of the Central Plain and throughout the Northern Highland. Trembling aspen is the primary tree species associated with Deciduous Clear Cuts. Additional tree and shrub species that are important components of clear cuts include ironwood, hazelnut, sugar maple, and basswood. Important ground layer species include black raspberry, big-leaf aster, rice grass, bottle-brush grass, Pennsylvania sedge, northern bedstraw, bracken fern, and wood anemone. In wet-mesic sites bunchberry and large-flowered trillium are also important.

Deciduous Clear Cuts and associated edge habitat probably support the greatest diversity of breeding birds among the habitats in the Valley. Principal breeding species include ruffed grouse, ruby-throated hummingbird, eastern kingbird, alder flycatcher*, house wren, gray catbird*, brown thrasher, eastern bluebird, golden-winged warbler*, Nashville warbler, yellow warbler, chestnut-sided warbler*, mourning warbler*, common yellowthroat*, Canada warbler*, brown-headed cowbird, rose-breasted grosbeak, indigo bunting*, American goldfinch, white-throated sparrow*, and song sparrow.

Coniferous Communities

Upland Coniferous Forest

Before settlement of the Valley most of the Central Plain and Northern Highland was covered with Upland Coniferous Forest. Logging activities during the late 1800's and early 1900's altered much of this habitat; very few stands of pure Upland Coniferous Forest still exist. Probably the best representative stands occur in and near St. Croix State Park in Pine County and Lucius Woods State Park in Douglas County. In most instances this habitat occurs as small relicts intermixed with several Upland Deciduous Forest species. This habitat type is included because of its past dominance and existing relict stands.

Principal tree species associated with Upland Coniferous Forest are white pine and red pine. Important invaders include white birch, trembling aspen, red maple, sugar maple, black cherry, hazelnut, and ironwood. Prevalent ground layer vegetation includes wood anemone, wild sarsaparilla, big-leaf aster, Pennsylvania sedge, blue bead lily, bunchberry, wintergreen, ground pine, Canada mayflower, partridge berry, starflower, Indian pipe, and dwarf ginseng.

Important breeding bird species of the Upland Coniferous Forest include sharp-shinned hawk, pileated woodpecker, hairy woodpecker, eastern wood pewee, blue jay, common raven, black-capped chickadee, red-breasted nuthatch, hermit thrush, black-and-white warbler, yellow-rumped warbler, pine warbler*, Blackburnian warbler*, ovenbird, purple finch, pine siskin, dark-eyed junco, and chipping sparrow.

Lowland Coniferous Forest

This habitat type occurs in numerous locations north of the Tension Zone. The frequency of the Lowland Coniferous Forest is high but is limited in extent, occurring primarily in three distinct topographic settings: river floodplains, ancient lake beds, and kettles associated with kettle and knob topography in morainal areas. Soils of this habitat are usually acidic and are composed of wet, decaying vegetation that in many instances gives the ground a spongy texture. This habitat type is similar in several respects to the original Boreal Forest. Because most of that habitat type has been destroyed or greatly altered, vegetative characteristics and breeding bird use of the two have been combined.

Principal tree species of the Lowland Coniferous Forest include white spruce, white cedar, balsam fir, yellow birch, black ash, and green ash. Tamarack, American elm, and occasionally red maple, are also important components of this habitat. Shrub layers are usually poorly developed in Lowland Coniferous Forest; green ash and mountain holly are usually the prevalent shrub species. Important species of the ground layer include blue bead lily, bunchberry, creeping snowberry, wintergreen, Labrador tea, Canada mayflower, false Solomon's seal, starflower, blueberry, wild cranberry, round-leaf sundew, downy yellow violet, and sphagnum moss.

Principal breeding birds of this community include pileated woodpecker, yellow-bellied flycatcher, olive-sided flycatcher*, black-capped chickadee, red-breasted nuthatch*, winter wren*, hermit thrush, veery, solitary vireo, black-and-white warbler*, Nashville warbler, northern parula*, magnolia warbler*, yellow-rumped warbler*, ovenbird, northern waterthrush, common yellowthroat, brown-headed cowbird, purple finch*, pine siskin, chipping sparrow, white-throated sparrow, and song sparrow.

Black Spruce–Tamarack Bog

Although not as extensive in distribution as other coniferous or deciduous habitats, bogs are important to a large variety of breeding birds. This community exists primarily north of the Tension Zone and becomes frequent in the Northern Highland. Scattered relict bogs also occur in northern St. Croix and Washington counties. Bogs are formed in ancient lake basins or in outwash associated with morainal deposits. Bog soils are poorly developed and are usually highly acidic, owing in part to anaerobic decomposition of vegetation and temperature.

Black spruce and tamarack are the two most important tree species in this community. Mountain holly and bog birch are the main shrub layer species. Ground-layer vegetation in these bogs is perhaps the characteristic that separates this community from all others. Usually, the most important family is Ericaceae (e.g., leatherleaf, Labrador tea). Herbaceous vegetation in bogs usually contains several carnivorous plants including pitcher plant and round-leaf sundew. Prevalent vegetation includes Labrador tea, leatherleaf, bog rosemary, bog laurel, wild cranberry, buckbean, sphagnum moss, cottongrass, awned sedge, brown sedge, and bluejoint grass.

Principal breeding bird species include olive-sided flycatcher, black-capped chickadee, red-breasted nuthatch, winter wren, veery, black-and-white warbler, Nashville warbler*, yellow warbler, yellow-rumped warbler, common yellowthroat, red-winged blackbird, brown-headed cowbird, purple finch, pine siskin, American goldfinch, chipping sparrow, white-throated sparrow, swamp sparrow, and song sparrow.

Jack Pine Barrens

This community exists throughout the northern portions of the Central Plain and Northern Highland. Extensive stands of Jack Pine Barrens occur on sandy soils associated with the bed of Glacial Lake Grantsburg in Burnett, Pine, and Polk counties. Curtis (1959) considered fire to be an important agent in the origin of Jack Pine Barrens. Soils are primarily sandy and stabilized by various grasses.

Principal tree species of Jack Pine Barrens include jack pine, red pine, Hill's oak, bur oak, large-toothed aspen, and trembling aspen. Sweet fern, New Jersey tea, and blueberry are the most important shrubs of this community. In many areas, blueberry becomes dominant over other shrubs and among the ground layer. Important ground-layer vegetation includes Canada bluegrass, Kentucky bluegrass, pearly everlasting, yarrow, bracken fern, dogbane, big-leaf aster, flowering spurge, whorled loosestrife, wintergreen, and bearberry.

Important breeding birds associated with Jack Pine Barrens are mourning dove, common flicker, blue jay, house wren, American robin, hermit thrush, yellow-rumped warbler, Nashville warbler, ovenbird, northern oriole, brown-headed cowbird, indigo bunting, rufous-sided towhee, chipping sparrow*, clay-colored sparrow, and field sparrow. Recent surveys indicate that the Connecticut warbler is a fairly common breeding species in localized areas of Jack Pine Barrens in northwestern and western Burnett County.

Pine Plantations

This artificial community has become an important avian habitat primarily in St. Croix and Washington counties. Large hectarages of cropland, hillsides, and Old Field Communities have been converted to Pine Plantations. The establishment of this community has accomplished three purposes: soil stabilization, ornamental plantings, and commercial Christmas tree production.

Pine Plantations are primarily monotypic stands of red pine and scotch pine. Occasional stands also include white pine. Size of these plantations usually range from 2 to 20 ha. During the early stages of establishment, ground-layer vegetation retains the character of the original habitat and can consist of Kentucky bluegrass, quackgrass, ragweed, bindweed, Virginia strawberry, and flowering spurge. Continued tree growth, low light, and increased soil acidity results in an almost complete lack of ground-layer vegetation development.

Principal breeding bird species include mourning dove*, blue jay, common crow, house wren, brown thrasher, American robin*, common grackle*, brown-headed cowbird, and chipping sparrow*.

Wetland Communities

Prairie Wetlands

Much of central St. Croix, southern Polk, north central Washington, and south central Chisago counties are dotted with small semipermanent and permanent wetlands. These wetlands occur on glacial outwash associated with the Wisconsin glacial epoch, which ended about 10,000 years ago. Upland soils associated with these wetlands are highly fertile loams and silt oams which are very important for agricultural production. Related to this, arge hectarages of Prairie Wetlands have been drained or seriously altered to facilitate expanding agricultural production.

Principal emergent and submerged aquatic vegetation associated with these freshwater, low-acidity wetlands include hardstem bulrush, softstem bulrush, river bulrush, cattail, cane reed, spikerush, burreed, coontail, and water milfoil. Other important species dependent on water permanence and the degree of acidity include arrowhead, water plantain, and reed canary grass.

Characteristic breeding birds associated with Prairie Wetlands include pied-billed grebe*, American bittern*, Canada goose*, mallard*, gadwall*, pintail*, green-winged teal*, blue-winged teal*, ruddy duck*, Virginia rail*, sora*, American coot*, black tern*, tree swallow*, long-billed marsh wren*, yellow warbler, common yellowthroat, yellow-headed blackbird*, red-winged blackbird*, swamp sparrow, and song sparrow.

Forest Bordered Wetlands

Although similar to Prairie Wetlands in geologic origin, Forest Bordered Wetlands are different in flora and fauna. This community is widespread throughout the area north of the Tension Zone. Forest Bordered Wetlands are usually similar in size, but much deeper than Prairie Wetlands, and the nterspersion of emergent and submerged aquatic vegetation is less pronounced. Acidity of the water in Forest Bordered Wetlands is generally greater than in Prairie Wetlands. Principal emergent and submerged aquatic vegetation associated with this community includes cattail, wild rice, iris, pickerelweed, arrowhead, water plantain, bladderwort, elodea, coontail, water milfoil, white waterlily, and yellow waterlily.

Characteristic breeding birds associated with these wetlands include common loon*, green heron, mallard, black duck*, wood duck, ring-necked duck*, hooded merganser, Virginia rail, belted kingfisher, tree swallow, long-billed marsh wren, yellow warbler, common yellowthroat, red-winged blackbird, brown-headed cowbird, swamp sparrow, and song sparrow.

Riparian Habitats

The streams and rivers of the Valley are well known for their recreational attractions. Among the important rivers are the Snake, Kettle, Willow, Apple, Clam, Namekagon, and Kinnickinnic. Numerous small streams that are tributaries of these larger rivers often provide excellent trout fishing. Breeding birds associated with streams and rivers may also be included in larger deciduous and coniferous communities. However, nesting strategies of several species are closely related to certain aspects of the ecology of moving water. Principal among these breeding birds are the great blue heron* (locally), mallard, wood duck*, hooded merganser*, spotted sandpiper*, belted kingfisher*, eastern phoebe*, rough-winged swallow*, cliff swallow*, American robin, yellow warbler, common yellowthroat, red-winged blackbird, and song sparrow.

Northern Sedge Meadow

This community occurs throughout the Valley and makes up a large proportion of the aquatic habitats. These wetlands occur primarily north of the Tension Zone. Northern Sedge Meadow usually forms on the bed of an ancient lake or along and adjacent to larger streams and rivers. Soils associated with this community consist primarily of decaying vegetation and have a low mineral content. Groundwater is usually at or near the surface, providing a spongy texture to the soil surface. Probably the largest and best developed examples of Northern Sedge Meadow are associated with the bed of Glacial Lake Grantsburg in Burnett and Pine counties.

Principal vegetation of this community includes foxtail sedge, crested sedge, inland sedge, slender sedge, tussock sedge, fox sedge, cattail, bluejoint grass, manna grass, and dark-green bulrush. Important forbs include marsh cinquefoil, marsh milkweed, purple-stem aster, marsh bellflower, spotted joe-pye weed, meadow sweet, and small bedstraw.

Northern Sedge Meadows do not support the diversity and abundance of breeding birds usually associated with other wetland types. However, several species breed in this community almost exclusively. Principal breeding species include American bittern, mallard, marsh hawk*, ring-necked pheasant, sandhill crane*, sora, common snipe*, short-billed marsh wren*, yellow warbler, common yellowthroat*, red-winged blackbird, brown-headed cowbird, LeConte's sparrow* (local), swamp sparrow, and song sparrow.

Alder Thicket and Shrub Carr

Both Alder Thicket and Shrub Carr communities are similar in geologic origin and flora. One major difference between these habitats is that alder is replaced by willow, particularly silver willow, in Shrub Carrs. Both habitat types are usually associated with ancient lake beds or the floodplains of streams and rivers. In many instances, these habitats develop from the invasion of woody shrubs in a Northern Sedge Meadow. Alder Thicket and Shrub Carr communities occur regularly throughout the Valley. However, there appears to be a predominance of Alder Thickets north of the Tension Zone, and Shrub Carrs occur most frequently within and south of the Tension Zone.

Principal vegetation associated with the Shrub Carr community includes silver willow and red-osier dogwood in the shrub layer. Common grasses and forbs include marsh shield fern, yellowish sedge, bluejoint grass, reed canary grass, manna grass, marsh milkweed, jewelweed, spotted joe-pye weed, water horehound, and meadowsweet. Characteristic breeding birds of Shrub Carr include mallard, blue-winged teal, marsh hawk, ring-necked pheasant*, common snipe, willow flycatcher*, short-billed marsh wren, veery, yellow warbler*, common yellowthroat, red-winged blackbird, brown-headed cowbird, swamp sparrow, and song sparrow.

Vegetation associated with Alder Thicket habitat includes speckled alder and red-osier dogwood in the shrub layer. Characteristic grasses and forbs include dark-green bulrush, tall manna grass, bluejoint grass, marsh milkweed, marsh bellflower, turtlehead, spotted joe-pye weed, jewelweed, field mint, and great water dock. Characteristic breeding birds of Alder Thicket include alder flycatcher*, tree swallow, gray catbird, veery*, golden-winged warbler, yellow warbler, northern waterthrush* (local), common yellowthroat, red-winged blackbird, swamp sparrow*, and song sparrow.

Agricultural Communities

Cropland

One of the most prominent aspects of the landscape in the lower Valley is the presence of agricultural fields. According to figures from the U.S. Department of Agriculture, there were at least 158,540 ha in the Valley devoted to row crop or cereal crop production (row crop = 62.6%, cereal crop = 37.4%) in 1967. By 1977, the totals had increased to 195,587 total ha 73.2% in row crops, 26.8% in cereal crops). Of the nearly 1.8 million ha of the Valley included in this report, 8.8% was devoted to row and cereal crop production in 1967 and 11% in 1977.

During the initial stages of agricultural development, important habitats ncluding native tall grass prairie, deciduous forest, and prairie wetlands were destroyed to accommodate expanded production. Changes in land use of the magnitude attributed to Cropland have had a serious impact on bird populations and bird species diversity. Current agricultural practices of fencerow to fencerow farming, clean farming, fencerow removal, and windbreak removal to facilitate center-pivot irrigation systems, produce additional stresses on bird populations.

Corn, soybeans, oats, barley, and to a limited extent, wheat, are the prominent crops produced in this region. Although a common practice in western Minnesota, summer fallowing the soil has only recently become popular in this region. Characteristic breeding bird species that use Cropland include gray partridge*, killdeer*, horned lark*, western meadowlark, red-winged blackbird, and vesper sparrow.

Hayland

Domestic hay was produced on 128,927 ha in 1967 and 139,393 ha (+7.5%) in 1977. Hayland accounted for 7.2 and 7.8% of the total area of the Valley in 1967 and 1977, respectively. This temporary habitat is important to a variety of early nesting species. Hayland is also important in soil conservation because the soil is not laid bare each year and is not exposed to the ravages of wind and water erosion as it is with row crops. Principal plant species used in hay production include alfalfa, timothy, brome grass, and red clover.

Characteristic breeding birds associated with Haylands include American bittern, mallard, blue-winged teal, pintail, marsh hawk, short-billed marsh wren, bobolink*, eastern meadowlark*, western meadowlark, red-winged blackbird, dickcissel*, savannah sparrow*, grasshopper sparrow*, Henslow's sparrow*, LeConte's sparrow, and song sparrow.

Old Field Community

The Old Field community represents a relatively small proportion of the land area in the Valley. This habitat type develops when land is taken out of agricultural production and allowed to develop by natural succession. Invasion by a variety of plants will result in a rapidly changing vegetational community. Areas of Old Field community are usually no larger than 16 ha; most are 4 to 8 ha.

Characteristic plant species associated with this habitat include a variety of pioneer trees and shrubs, such as trembling aspen, box elder, staghorn sumac, and flowering crab apple. Grasses and forbs associated with this habitat include timothy, awnless bromegrass, Kentucky bluegrass, quackgrass, big bluestem, little bluestem, hoary alyssum, blue vervain, moth mullein, yarrow, evening primrose, common milkweed, alfalfa, goat's beard, sheep sorrel, daisy fleabane, noble goldenrod, and sharp-toothed goldenrod.

Characteristic breeding birds associated with this habitat include American kestrel, mourning dove, eastern kingbird*, brown thrasher, eastern bluebird, golden-winged warbler, yellow warbler, eastern meadowlark, brown-headed cowbird, indigo bunting, American goldfinch, rufous-sided towhee, clay-colored sparrow*, field sparrow*, and song sparrow.

Managed Grasslands

Within the Valley, several thousand hectares of upland fields have been acquired by State and Federal conservation agencies as wildlife management areas or Waterfowl Production Areas. These lands are usually agricultural fields that have been taken out of production. Several different management techniques are used to develop extensive areas of grasses and forbs to provide nesting habitat for a variety of wildlife species.

Characteristic plant species established on Managed Grassland areas include intermediate wheatgrass, switchgrass, timothy, and brome grass. After establishment of these grasses, a number of forbs invade the areas. Several characteristic invaders include hoary alyssum, yarrow, blue vervain, daisy fleabane, and sharp-toothed goldenrod.

These established communities provide habitat for a variety of species including American bittern, mallard, pintail, blue-winged teal, marsh hawk, ring-necked pheasant, short-billed marsh wren, common yellowthroat, bobolink, eastern meadowlark, western meadowlark, red-winged blackbird, dickcissel, and savannah, grasshopper, Henslow's, vesper, and song sparrows.

Residential Habitats

Small towns and cities scattered throughout the Valley provide a diversity of habitats for breeding birds. Intermixed with concrete buildings are areas of hedgerows, row trees, tree groves, lawns, and parks. Diverse food sources, ranging from feed mills and lawns to gardens and bird feeding stations, add to the vegetation available for breeding birds.

Characteristic birds associated with Residential Habitats include rock dove*, mourning dove, screech owl, common nighthawk*, chimney swift*, downy woodpecker, purple martin*, blue jay, black-capped chickadee, white-breasted nuthatch, house wren, gray catbird, brown thrasher, American robin, starling*, house sparrow*, northern oriole, common grackle, cardinal, rose-breasted grosbeak, and American goldfinch.

Methods, Terminology, and Nomenclature

The counties covered in this report include Chisago, Pine, and Washington in Minnesota and Burnett, Douglas (part), Pierce, Polk, and St. Croix in Wisconsin. References made to a species status or occurrence in the Valley will pertain to these counties. Ideally, a complete coverage of the birds occurring in this region would include records for all counties within the watershed. However, because many records are not discernible to exact locations within a county (in or out of the watershed) I have, for conformity, included bird records only for counties that border on the St. Croix River.

Foremost among the published sources of data on bird occurrence and distribution presented in this report were the *Loon* and its predecessor, the *Flicker*, the quarterly publication of the Minnesota Ornithologists Union, and the *Passenger Pigeon*, the quarterly publication of the Wisconsin Society for Ornithology. Important papers dealing with species or species groups have been published in these journals and extensive use was made of the data contained therein. Considerable use was made of published reports in *American Birds*, the field report publication of the National Audubon Society. Probably the most important contribution of *American Birds* to the present report was the yearly publication of Christmas Bird Counts (CBC) conducted in both States.

I conducted field work in this region from 1966 through 1978, and intermittently during 1979–80. Before 1969, most observations were made in northern Polk, southern Douglas, Burnett, and eastern Pine counties. During 1969–76, field work was expanded to include the remainder of the counties and intensive observations were started on several species in Pierce, St. Croix, and Washington counties. Many of the dates of occurrence and statements on abundance and distribution were derived largely from my unpublished field notes. The unpublished field notes of Rev. Samuel Robbins for 1960–68 in St. Croix, Polk, and Pierce counties were also examined extensively. Several State parks and wildlife management areas in both States were visited and some limited data (with the exception of the Crex Meadows Wildlife Area) were made available.

Data on breeding and winter status were gathered from three sources. First, intensive field work by several previous investigators and me led to the discovery of numerous nests or dependent young. These observations provide the foundation for species status remarks and habitat use of breeding birds. Secondly, the U.S. Fish and Wildlife Service, Migratory Bird and Habitat Research Laboratory, Laurel, Maryland, has established a number of BBS transects throughout North America (Robbins and Van Velzen 1967). These 39.2-km transect routes are selected at random and are censused once each year during June. Five transect routes were established in the Valley; unfortunately, all five are in Wisconsin (Fig. 4). Data from these routes are presented to point out regions of peak populations of several species and, in some instances, to show geographic differences in species breeding distribution. Third, CBC sponsored by the National Audubon Society provide an important source of data on winter bird populations and geographic differences in species abundance. At least eight CBC areas have been established within the Valley. However, only five (Fig. 5) have been

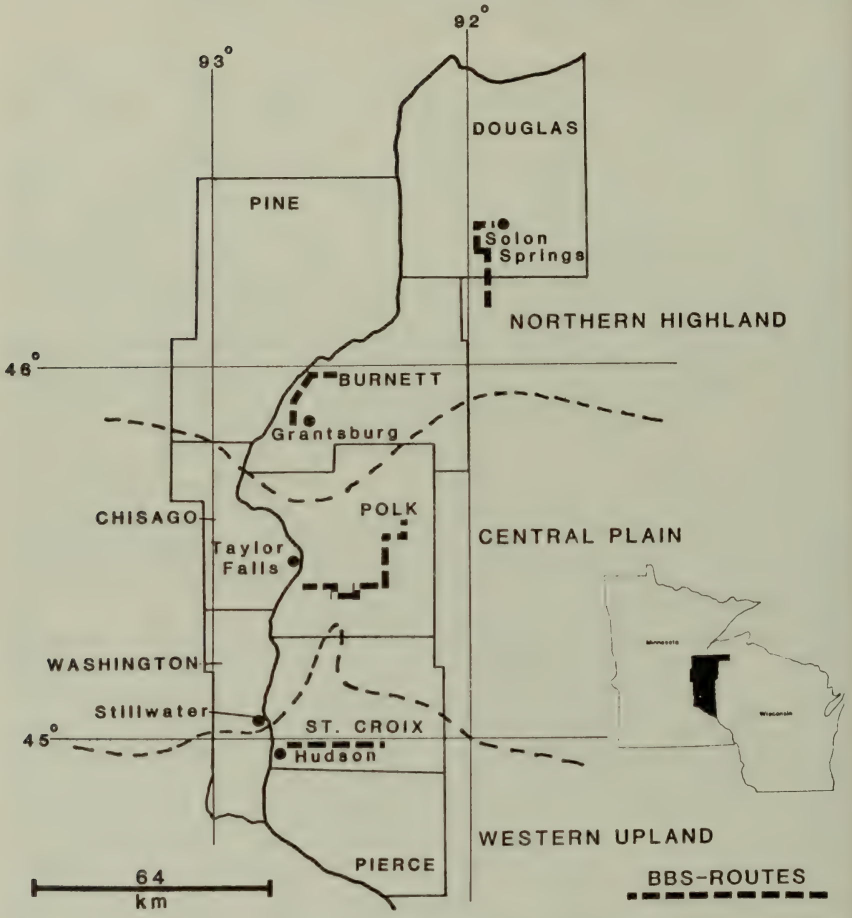


Fig. 4. Location of Breeding Bird Survey routes in the St. Croix River Valley.

counted for a sufficient number of years to allow meaningful comparisons.

Terms

Considerable conjecture and argument has developed about what is the best method for describing a species occurrence, regularity, and abundance. Terms are treated under three categories: status, season, and abundance. The terms used to describe each species status in the present report are adapted from those presented in Green and Janssen (1975), including

Regular—A species that occurs at some location in the Valley during at least one season each year.

Casual—A species expected to occur at least once every 3 to 5 years, but not annually.

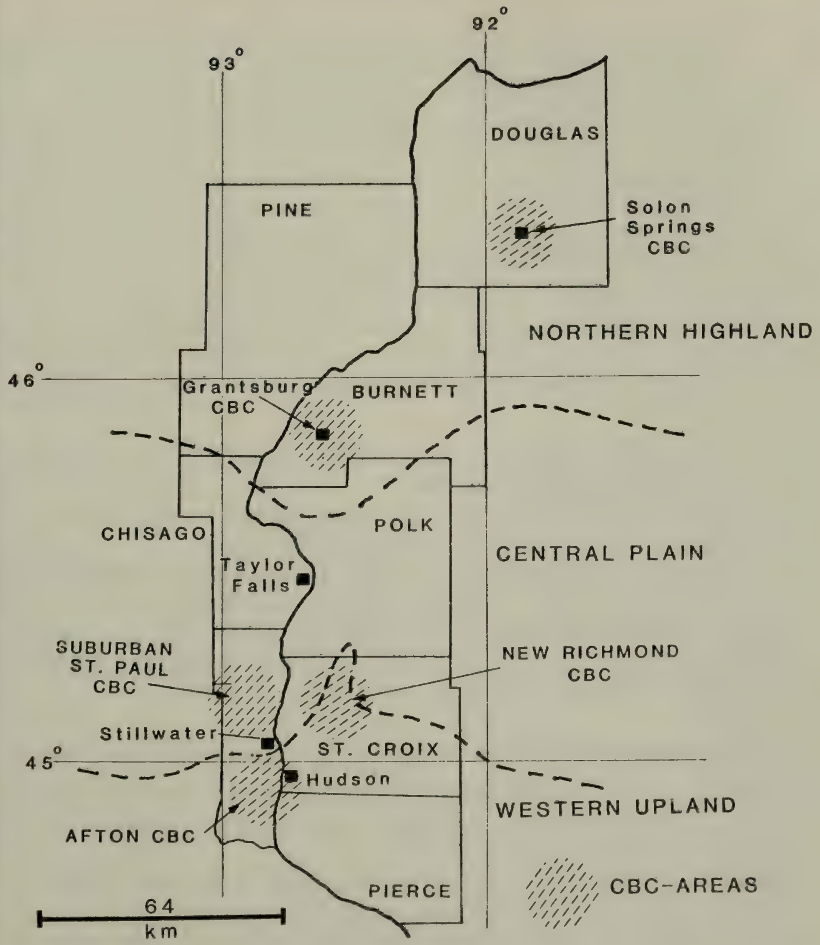


Fig. 5. Location of major Christmas Bird Count areas in the St. Croix River Valley.

Accidental—A species that is not expected to occur again or that occurs very infrequently.

Hypothetical—A species that probably occurred in the Valley at least once, but the circumstances of the observation leave the record in doubt.

Introduced—A species that is naturally foreign to this region but has been released in the area as an act of man and is now established and reproducing without additional influence by man.

Extirpated—A species that once occurred naturally in the Valley, has now been eliminated, but still exists elsewhere. This term applies to both migrants and nesting species.

Extinct—A species that no longer exists anywhere on earth.

The population status of several species has recently become a concern of the public. Legal protection for all birds except the rock dove, starling, and house sparrow has been provided by the Federal Government by the Migratory Bird Treaty Act of 1918, as amended (40 Stat. 755; 16 U.S.C. 703-711). Eagles have been afforded additional protection by the Eagle Act of 1940 (54 Stat. 250; 16 U.S.C. 668). Several species have been given even greater protection by the Federal Endangered Species Act of 1973 (87 Stat. 884; 16 U.S.C. 668aa-668cc). Both Minnesota and Wisconsin have enacted special legislation within their respective States that provides statewide protection for species that are declining locally or regionally, but not on a level to be afforded protection by the Endangered Species Act of 1973.

Official lists of protected bird species have been prepared for Minnesota and Wisconsin. Forty-three of the species listed by either State have been recorded in the Valley (Table 1). Terms used throughout this report to describe the special status of these species are adapted from Les (1979) and Moyle (1980).

Endangered—A species whose continued existence is in jeopardy and is provided special protection by law.

Threatened—A species that appears likely to become endangered. Threatened species are provided special protection by law.

Watch—A species for which some problem of abundance is suspected but not proven. The purpose of this classification is to focus attention on a species before it becomes threatened or endangered. This is an informal classification and no additional legal protection is provided. In Minnesota, species in this classification are considered *Priority.*

Terms used in describing the occurrence of a species in the Valley include

Permanent resident—A species that is largely nonmigratory or, if migratory, only a very small proportion of the population departs during a migration period.

Migrant—A species that normally occurs in the Valley only during the well-defined spring and fall migration period.

Nesting species—A species for which a viable clutch of eggs, dependent young in the nest, or young that have left the nest but are still dependent have been observed.

Summer resident—A species that occurs in the Valley during the normal nesting period and in all likelihood nests, but for which there are no confirmed records of eggs or dependent young.

Winter resident—A species that winters even though greater numbers may occur during migration.

Terms used in relating the relative abundance of each species during migration, winter, or the breeding season relate to its importance to the total avifauna. These terms adapted from Stewart (1975) are described as follows:

Abundant—A species that, because of its habits and conspicuousness, occurs in very large numbers.

Common—A species that occurs in large numbers.

Fairly common—A species that occurs in fair to moderate numbers.

Uncommon—A species that is found in low numbers.

Table 1. *Endangered (E), threatened (T), priority (P), and watch (W) species in the St. Croix River Valley.*

Species	Minnesota	Wisconsin
Common loon		W
White pelican	P	
Double-crested cormorant		E
Great egret		T
Snowy egret	P	
Great blue heron		W
Black-crowned night heron		W
Yellow-crowned night heron	P	
Black duck		W
Red-breasted merganser		W
Cooper's hawk		T
Marsh hawk	P	W
Red-shouldered hawk		T
Bald eagle	T	E
Osprey		E
Peregrine falcon	E	E
Merlin	P	W
Spruce grouse		W
Sharp-tailed grouse		W
Greater prairie chicken	P	T
Bobwhite	T	
Yellow rail	P	W
King rail	T	
American avocet	P	
Piping plover	T	E
Marbled godwit	P	
Upland sandpiper	P	W
Common tern	P	E
Forster's tern		E
Caspian tern		W
Black tern		W
Great gray owl	T	
Short-eared owl	P	
Common flicker		W
Black-backed three-toed woodpecker	P	
Bewick's wren		W
Eastern bluebird	P	W
Loggerhead shrike		T
Dickcissel		W
Grasshopper sparrow		W
Baird's sparrow	P	
Sharp-tailed sparrow	P	
Vesper sparrow		W
Field sparrow		W

Rare—A species whose range includes the Valley but is recorded in low numbers.

Very rare—A species that occurs in such low numbers that it is of minor importance.

Table 2. *Classification of wetland types in the St. Croix River Valley. This classification follows Cowardin et al. (1979) and Curtis (1959).*

Wetland name used in this report	Wetland type (Shaw and Fredine 1956)	Water chemistry	Authority
Temporarily flooded	1	Fresh	Cowardin et al.
Northern sedge meadow	2	Fresh	Curtis
Seasonally flooded	3	Fresh	Cowardin et al.
Semipermanently flooded	4	Fresh	Cowardin et al.
Permanently flooded	5	Fresh	Cowardin et al.
Shrub carr	6	Fresh	Curtis
Bog	8	Acidic	Curtis

Nomenclature

The taxonomic treatment of birds presented in this report follows the American Ornithologists' Union (AOU) *Check-list of North American Birds* (1957), and the 32nd (AOU 1973) and 33rd (AOU 1976) supplements to the Check-list. One deviation from the AOU standard sequence is presented for the shorebirds. In this instance, I followed the sequence recommended by Jehl (1968).

Description of the major plant communities of the Valley follows Curtis (1959). Major habitats used by each species were determined from personal field investigations and from published reports. The taxonomic names of plants described in the habitat sections are those used in Gleason and Cronquist (1956). Common names of some plant species, primarily grasses and sedges, are taken from Britton and Brown (1913). Voucher specimens of most of the important grasses and forbs used in this report are housed in the Herbarium, Department of Biology, University of Wisconsin—River Falls.

The wetland classification used in this report (Table 2) is a combination of the systems developed by Cowardin et al. (1979) and Curtis (1959). Cowardin et al. (1979) employ a hierarchical system with modifiers for water regime, water chemistry, and soil type. Three wetland types (Northern Sedge Meadow, Shrub Carr, and Bogs) were named and classified by Curtis (1959). Because these names are widely used and accepted in the Valley, I have deviated from Cowardin's system in that instance.

Species Accounts

FAMILY GAVIIDAE: Loons

Common Loon (*Gavia immer*)

Status: Regular migrant and nesting species.

Migration: Common (locally abundant) during spring and fall throughout the Valley. Spring migrants arrive in the Western Upland during the first week of April (earliest—4 April 1964, St. Croix County; Soulen 1965) and the Northern Highland 10–15 April. Peak spring abundance occurs 20 April to 1 May. During this period flocks of 5 to 10 birds are common and flocks totaling 15 to 20 are occasional on larger lakes. Spring departure from the southern one-third of the Valley occurs by 15 May. Fall migrants arrive in the Western Upland during the first week of October and remain until water on the larger lakes freezes in late November. No major common loon staging areas exist in this region, resulting in relatively small numbers observed during the fall.

Nesting Season Distribution: Uncommon nesting bird on larger lakes and marshes of the Northern Highland, rare and local in the Central Plain. Casual summering birds near Roberts, St. Croix County, indicate possible nesting although no broods have been observed. Longley (1949) reported a pair with one young in Washington County on 17 June 1949. Additional Washington County brood records were obtained in 1970 and 1971 (Eckert 1971).

Habitat: Common loons are primarily a species of large permanently flooded wetlands, particularly those containing small islands. Most wetlands used for nesting are bordered by deciduous forest, chiefly trembling aspen and maple, and contain peripheral zones of emergent aquatic vegetation. At the Crex Meadows Wildlife Area in Burnett County, common loons nest on semipermanently and permanently flooded wetlands. The vegetation consists primarily of cattail and various species of sedge. Evrard et al. (1978) found that common loons at Crex Meadows occupied wetlands that ranged from 6.9 to 324 ha.

Concern has been expressed recently about the population status of this species in Wisconsin, Minnesota, and other northern States. The primary threat to the nesting habitat of this species is shoreline development surrounding nesting lakes.

Red-throated Loon (*Gavia stellata*)

Status: Casual migrant; one summer record.

Records: Spring records include Pierce County—10 May 1967; St. Croix County—25 April 1962 and 17 May 1965; Burnett County—15 May 1950 (Robbins 1950*b*). During the summer of 1953 a nonbreeding red-throated loon was observed on 11 June and 17 July at Crex Meadows Wildlife Area, Burnett County.

FAMILY PODICIPEDIDAE: Grebes

Red-necked Grebe (*Podiceps grisegena*)

Status: Regular migrant and nesting species.

Migration: Rare spring and fall migrant in the Western Upland, casual or absent elsewhere. Spring migrants arrive during the second week of April (earliest—8 April 1959, Burnett County). Dates of peak abundance cannot be determined because of low numbers. Nonbreeding migrants have departed by 20 May. The first fall migrants arrive 25 September to 5 October and the last depart by 1 November (latest—10 November). During both seasons migrants are usually observed in central St. Croix County and at several areas along the St. Croix River in Washington, Polk, and St. Croix counties.

Nesting Season Distribution: The red-necked grebe is a very rare and local nesting species. Green and Janssen (1975) showed a nesting record for Washington County. Apparently this species no longer nests on the Minnesota side of the St. Croix River. Presently, nesting occurs only on prairie wetlands in central St. Croix and extreme southern Polk counties.

The first nesting for the Valley in Wisconsin was recorded in 1973 from East Twin Lake near Roberts. During the summer of 1976, three pairs produced young on Twin Lakes and an additional pair was successful on Oakridge Lake near New Richmond. In 1977, four pairs produced young on Oakridge Lake, one pair on East Twin Lake, and a sixth pair produced young on a small wetland near Star Prairie in Polk County. During 1978–79 breeding populations were greatly reduced with activity restricted to Oakridge Lake (M. Schmidt, personal communication).

Habitat: All 12 nesting records have been obtained on semipermanently and permanently flooded wetlands. These wetlands range in size from 8.5 to 93 ha. Extensive beds of submerged aquatic plants are present on these wetlands. All nests have been located in large beds of softstem bulrush.

Horned Grebe (*Podiceps auritus*)

Status: Regular migrant, casual nesting species.

Migration: Common migrant throughout the Valley. Spring migrants begin to arrive in the Western Upland during the second week of April (earliest—24 March) and the Northern Highland 1–5 May. Peak abundance occurs during the first week of May and departure by 15 May. Fall migrants begin to arrive during the third week of September. Peak abundance occurs about 15 October when occasional flocks of 50 to 60 individuals are observed on larger lakes. Fall migrants have departed by November 20.

Nesting Season Distribution: One nesting record exists for this region. On 2 July 1951 an adult with a brood of four was observed at the Crex Meadows Wildlife Area, Burnett County. On 14 June 1974, I observed an adult in breeding plumage near Range, Polk County.

Habitat: Horned grebes use a wide range of wetland classes including seasonally, semipermanently, and permanently flooded wetlands. In the Northern Highland, extensive use is made of Forest Bordered Wetlands and occasional use is made of acidic bog wetlands and larger rivers. The Burnett County nesting pair were using a large sedge meadow wetland.

Eared Grebe (*Podiceps nigricollis*)

Status: Regular spring and casual fall migrant; four summer records.

Migration: Rare migrant in the Western Upland and Central Plain. There are no records except from Crex Meadows in the Northern Highland. Spring migrants begin to arrive during the last week of April (earliest—20 April 1975, Polk County) and remain through 5 June. Sightings are most often of single or paired birds. Dates for fall migrants are too few to establish a pattern. Fall observations are rare, noted between 10–20 September.

Nesting Season Distribution: One nesting record exists for the Valley. S. D. Robbins found an adult carrying young on its back during the summer of 1968 on East Twin Lake near Roberts, St. Croix County (Robbins 1969*a*). This is the only known nesting record of the eared grebe in Wisconsin. On 21 July 1952, three eared grebes were observed on Phantom Lake, Crex Meadows, and on 12 July 1956, a single bird was observed at Crex Meadows (Lound and Lound 1956*b*). During the summer of 1977, a single adult remained on Oakridge Lake, St. Croix County, until 8 August.

Habitat: Eared grebes in the Valley have been found primarily on large permanently flooded wetlands with extensive growths of emergent and submerged aquatic vegetation. The St. Croix County nesting pair used a large semipermanently flooded wetland. Vegetation of that wetland was characterized by extensive beds of coontail surrounded by hardstem bulrush and cattail.

Western Grebe (*Aechmophorus occidentalis*)

Status: Casual migrant.

Records: Western grebes have been observed twice in spring and once in fall at Crex Meadows, Burnett County. The first record was 30 May 1974, and the second 8 June 1976. The fall observation was on 26 August 1975. All Crex Meadows records were obtained from the Phantom Lake flowage. J. O. Evrard observed a single western grebe on the Fish Lake Wildlife Area near Grantsburg, Burnett County, on 3 June 1979. This bird was observed on Crex Meadows on 11 June 1979 (Tessen 1979*b*). This species has been recorded three times in St. Croix County: 2 October 1976, two birds on Oakridge Lake near New Richmond; 6 October 1967, three birds on Cedar Lake near Star Prairie; and 12 October 1974, on Oakridge Lake.

Pied-billed Grebe (*Podilymbus podiceps*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Western Upland and Central Plain, fairly common in the Northern Highland. Spring migrants arrive during the last week of March (earliest—9 March 1957, Burnett County). Peak abundance occurs 20 April to 1 May. During peak migration, concentrations of 75 to 100 individuals occur on several larger lakes in Chisago, Polk, and Burnett counties. Fall migrants begin to concentrate in early September. Peak fall abundance occurs during the second week of October and departure by 10 November (latest—19 December 1974, Pierce County).

Nesting Season Distribution: Common nesting species throughout the Valley. The largest numbers occur on prairie wetlands of the Central Plain and in the extensive marshes of southwestern Burnett County.

Habitat: The pied-billed grebe occurs most commonly on seasonally and semipermanently flooded wetlands with lush stands of emergent aquatics; cattail and bulrush appear to be preferred for nesting. Nesting pied-billed grebes are also found on large permanently flooded and Alder Thicket wetlands in the Northern Highland. Breeding populations in these habitat types are lower than on seasonally or semipermanently flooded wetlands.

FAMILY PELECANIDAE: Pelicans

White Pelican (*Pelecanus erythrorynchos*)

Status: Casual migrant.

Distribution: White pelicans have been observed in the Valley at least 10 times: St. Croix County—28–30 April 1941 (Schorger 1954), May 1950, and 2–6 November 1975 (Lesher 1976). Polk County—23 April 1867 (Schorger 1954), and 24 April to 12 June 1947. Burnett County—10 July 1970 (Crex Meadows files), and 30 October 1883 (Schorger 1954). Washington County—16 April 1976. Chisago County—about 60 white pelicans were observed migrating upstream at Taylor's Falls on 14 April 1979 (Turner 1979). Pine County—18 September 1972 (M. Link, personal communication).

Habitat: Most records of white pelicans have been of birds using large lakes, man-made impoundments, or open stretches of the St. Croix River.

FAMILY PHALACROCORACIDAE: Cormorants

Double-crested Cormorant (*Phalacrocorax auritus*)

Status: Regular migrant and nesting species. The Wisconsin Department of Natural Resources (WDNR) has listed this species as endangered (Les 1979). Loss of nest trees, use of pesticides, and human disturbance are listed as reasons for their decline.

Migration: Rare and local migrant throughout the Valley. Formerly a common to abundant migrant throughout its range, populations of double-crested cormorants have experienced alarming declines. Records exist of "flocks of thousands" migrating north along the Mississippi and St. Croix rivers until the 1950's. Currently, observers are fortunate to find more than 25 individuals during the year. The average date of spring arrival is 18 April (earliest—4 April 1976, Chisago County). Peak spring migration occurs 25 April to 10 May, and departure from nonbreeding areas by 25 May. Peak fall migration occurs between 10–20 September and departure by 15 October (latest—3 November 1975, Burnett County).

Nesting Season Distribution: Double-crested cormorants are rare and local during the nesting season in this region, currently known to nest only at the Crex Meadows and Fish Lake Wildlife Areas in Burnett County. The first esting was noted at Crex Meadows in 1968. This colony was in a heron ookery on Phantom Lake. Because of degradation of nesting trees, the hantom Lake colony declined, and birds moved to the Grettum Flowage at ish Lake Wildlife Area. In 1973, 23 nests were observed in the Grettum lowage colony.

abitat: Both Phantom Lake and Grettum Flowage are large impound- nents characterized by deep water and dead trees. This temporary habitat ype was created when tree growth in these basins was inundated by rising mpounded waters. Construction of nest platforms in the Phantom Lake olony has attracted several breeding pairs. This management practice may rove essential in the maintenance of these two colonies.

AMILY ARDEIDAE: Herons and Bitterns

reat Blue Heron (*Ardea herodias*)

tatus: Regular migrant and nesting species, casual winter resident.

igration: Common migrant in the Western Upland and Central Plain, ncommon and local in the Northern Highland. Spring migrants arrive in he Western Upland about 10 March (earliest—1 March 1969, St. Croix ounty) and reach the Northern Highland by 1 April. Peak migration occurs –20 April. Fall migration begins in mid-July with the gradual dispersal of oung from rookeries. Peak fall migration occurs 25 August to 30 Septem- er and most depart by 10 November (latest—20 November 1964 and 9 De- ember 1971, Burnett County).

esting Season Distribution: Fairly common and local nesting species hroughout the Valley. Evidence of nesting has been documented in all counies except Pierce. The two largest rookeries in the region are at Crex eadows Wildlife Area, Burnett County, and at Pine Lake, Pine County. At east four rookeries were active in Burnett County in the late 1940's and arly 1950's (Williams 1957). The Crex Meadows rookery located on hantom Lake was first used in 1952 (Williams 1957). Further records elated to the breeding population of this rookery follow:

1958—157 active nests
1960—108 active nests
1962—109 active nests
1968—160 active nests. Rainstorm (8.5 cm) on 30 June left 65 nests in the rookery. About 150 herons were found dead near the rookery.
1973—169 active nests, Phantom Lake; 13 active nests, North Fork Flowage
1974—143 active nests in four rookeries
1975—75 active nests in the Phantom Lake rookery
1976—31 active nests

Deterioration of nest platform trees is the primary cause of the rookery ecline at Crex Meadows. Attempts at placing artificial nest platforms for reat blue herons on the Phantom Lake rookery have been successful in ttracting double-crested cormorants. However, the great blue herons have not reestablished to former levels.

Winter: Three winter records exist for St. Croix County: 2 January 1961; 1 January 1971; and 1 January 1972. All birds were recorded on the Afton CBC.

Habitat: Most nesting rookeries in this region exist as small colonies built on dead or dying deciduous trees near natural lakes. The Burnett County colonies are in decaying trees associated with man-made impoundments. As evidenced by the continual changes in colony size and location of breeding populations at Phantom Lake, these temporary habitats are in a constant state of deterioration. In the Western Upland, several small rookeries exist in living green ash and American elm associated with the Lowland Deciduous Forest community. One rookery in the Northern Highland is in living white pine trees close to the St. Croix River in Burnett County.

Green Heron (*Butorides striatus*)

Status: Regular migrant and nesting species.

Migration: Common migrant in the Western Upland, primarily on the prairie wetlands of St. Croix, Washington, and southern Polk counties. Fairly common in the Central Plain, and uncommon and local in the Northern Highland. Spring migrants begin to arrive during the last week of April (earliest—6 April 1975 and 12 April 1964, Washington County). Average date of first arrival in Burnett County is 10 May, reaching Douglas County by 15 May. Peak spring abundance occurs 5–20 May. Fall migration begins in mid-August with formation of loose flocks. Peak fall movements occur 1–15 September. Green herons depart the Northern Highland by 15 September and the Western Upland by 10 October (latest—27 October 1975 and 9 November 1965, Washington County).

Nesting Season Distribution: Fairly common nesting species in the Western Upland, particularly the prairie wetland region of St. Croix, Washington, and southern Polk counties. Uncommon in the Central Plain, and rare and local in the Northern Highland. Substantial breeding populations occur in the marshes of Glacial Lake Grantsburg in Burnett County. Roberts (1932) cited a June 1919 nest containing three young in Pine County. Documented breeding records exist for all counties in the river valley except Chisago and Douglas. Jackson (1941) failed to record this heron during the 1919 breeding season in northwestern Wisconsin.

Habitat: Breeding green herons utilize a variety of habitats for nesting. In the Western Upland, breeding pairs and nests are typically observed in seasonally, semipermanently, and permanently flooded wetlands, and riverine habitats. In the Central Plain, breeding green herons are found typically in seasonally and semipermanently flooded wetlands, but also occupy Shrub Carr wetlands with a scattering of open water areas.

Little Blue Heron (*Florida caerulea*)

Status: Accidental, one record.

ecord: One adult was seen near Dunroven, Washington County, on April 1962 (Huber 1962). Because of the recent noticeable expansion of is species in the upper Midwest, I would expect this species to be recorded ore regularly in the future.

attle Egret (*Bubulcus ibis*)

tatus: Casual migrant.

ecords: The first cattle egret record for the Valley was obtained in Chisago ounty on 7 May 1971, when six birds were observed. One was observed in ashington County on 25 April 1977 (Savaloja 1977). In Pierce County a ngle bird was observed near River Falls on 28 April 1976. At Crex eadows, Burnett County, groups of four birds each were observed on –28 May 1974 and 16 April 1976. J. O. Evrard reported that cattle egrets ere present during July 1979 at Crex Meadows (Tessen 1979*b*).

reat Egret (*Casmerodius albus*)

tatus: Regular migrant and nesting species. The Wisconsin DNR has listed is species as threatened (Les 1979). Wetland drainage, loss of mature nest ees, pesticides, and human disturbance are listed as reasons for the ecline.

igration: Uncommon migrant in the Western Upland, rare and local in the entral Plain. Except in the vicinity of Crex Meadows, Burnett County, this ecies is rare north of a line extending from Chisago to northeastern St. roix counties. First spring migrants arrive in the Western Upland 10–15 pril (earliest—29 March 1968) and in Burnett County about 20 April. One olk County record was obtained on 10 April 1970. Fall migration begins in id-August. Peak fall populations occur 25 August to 10 September and eparture by 10 October (latest—30 October 1970 and 31 October 1956, urnett County).

esting Season Distribution: Rare and local nesting species with docu- ented breeding records from Washington, St. Croix, and Burnett counties. stablishment of this bird as a breeding species has been fairly recent. Jack- on (1941) failed to observe great egrets during 1919 in northwestern Wis- onsin. Roberts (1932) described the great egret as "occasionally a straggler om the south," yet cites no records from the Minnesota counties. The first ecord for the Valley is provided by King (1949), who reported this species at rescott, Pierce County, in 1946. Great egrets were first reported at Crex eadows, Burnett County, in 1948. Later, summer observations ranged om 19 in 1956 to 1 in 1969. Nesting at Crex Meadows was first recorded on 5 June 1975 (Evrard 1975). Since 1975, a small nesting colony has remained n the Fish Lake Wildlife Area, Burnett County. In Washington County, esting has been established with a colony of undetermined size (Green and anssen 1975). St. Croix County breeding records were established in 1976 hen two young were seen feeding with adults along Ten Mile Creek on 1 July. These birds nested in a small great blue heron colony along the

Willow River near New Richmond.

Habitat: Washington and St. Croix county colonies exist in live trees of Lowland Deciduous Forest. Nests at Fish Lake Wildlife Area occur in jack pine trees killed by the rising waters of Grettum Flowage.

Snowy Egret (*Egretta thula*)

Status: Accidental, one record.

Record: Norman Stone observed a single snowy egret at Crex Meadows, Burnett County, on 4 and 5 May 1959 (Stone 1959*a*).

Louisiana Heron (*Hydranassa tricolor*)

Status: Accidental, one record.

Record: One Louisiana heron was observed at Crex Meadows, Burnett County, on 7 July 1977 (Tessen 1977).

Black-crowned Night Heron (*Nycticorax nycticorax*)

Status: Regular migrant and nesting species.

Migration: Uncommon and local migrant in the Western Upland, rare in other regions. Spring migrants arrive in the Western Upland 10–15 April, reaching peak abundance 1–10 May. Average date of spring arrival in Burnett County is 10 May. Fall migration begins 25 August to 1 September and departure by 1 October (latest—28 November 1967, Washington County).

Nesting Season Distribution: Rare and local nesting species. Confirmed breeding records have been reported only from St. Croix and Burnett counties; however, several summer observations have been made in Washington County. Roberts (1932) stated that one of the most northerly colonies in Minnesota occurred on the St. Croix River in Pine County. Unfortunately no dates or locations are provided.

Habitat: Three nesting colonies of black-crowned night herons are known in this region. Habitats associated with these colonies include wetland habitat dominated by bulrush and cattail. In proximity are small groves of alder and willow used for nest platforms.

Yellow-crowned Night Heron (*Nyctanassa violacea*)

Status: Accidental, one record.

Record: Green and Janssen (1975) cite a 6 June 1964 record from St. Croix State Park, Pine County.

Least Bittern (*Ixobrychus exilis*)

Status: Regular migrant and nesting species.

igration: Uncommon migrant in the Western Upland and Central Plain. irst spring migrants arrive 5–10 May and are most frequently observed)–25 May. Fall migration begins 15–25 August and departure by 25 Sep- mber.

esting Season Distribution: Uncommon nesting species in the Western pland, uncommon to rare and local in the Central Plain. Documented reeding records exist for St. Croix County (three nests), Polk County (one est), and Burnett County (one nest). Summer observations of adults in Chi- go and Washington counties provide inferred evidence of nesting in those unties.

abitat: Principal nesting habitat of the least bittern includes semiperma- ently and permanently flooded wetlands. Nests observed in St. Croix and olk counties were in extensive stands of hardstem bulrush and river bul- ısh. The Burnett County nest was in a mixed stand of cattail and river ulrush.

merican Bittern (*Botaurus lentiginosus*)

tatus: Regular migrant and nesting species, accidental in winter.

igration: Fairly common spring and fall migrant in the Western Upland ıd Central Plain, uncommon and local in the Northern Highland. Spring igrants arrive 10–20 April (earliest—4 April 1974, Burnett County), reach- g peak abundance 1–5 May. Fall migration begins about 15 August in the orthern Highland and 25 August to 1 September elsewhere. Peak numbers cur 1–20 September. Departure from the Northern Highland occurs) September to 1 October; departure elsewhere is 10–25 October.

esting Season Distribution: Fairly common and well distributed in all gions. Breeding pairs occur with greatest frequency in the prairie wetland gion of St. Croix, Polk, and Washington counties, and at Crex Meadows, urnett County. Documented nest records exist for St. Croix, Polk, Bur- ett, and Washington counties. Evidence of nesting exists for the remaining unties. Jackson (1941) reported flushing one American bittern from a arsh at the headwaters of the St. Croix River in Douglas County on 8 Au- ıst 1919.

'inter: Wayne Norling observed a single bird at Crex Meadows, Burnett ounty, on 9 January 1976.

abitat: American bittern breeding habitat use varies with geographic rovince. Typical breeding habitat in Western Upland includes seasonally, emipermanently, and permanently flooded wetlands. Vegetation associated ith these wetlands includes river bulrush, cattail, softstem bulrush, hard- em bulrush, and phragmites. Preferred habitat in the Central Plain is simi- r with a higher percentage of reed canary grass in seasonally flooded wet- nds. Occasionally this species uses upland fields including Haylands, oat elds, Managed Grasslands, and retired cropland for nesting. In the north- n regions of the Central Plain and throughout the Northern Highland, reeding habitat includes cattail-bulrush marshes. A high percentage of breeding pairs occur in sedge meadows in this region, as well as edges of Black Spruce–Tamarack Bog and northern Forest Bordered Lakes.

FAMILY ANATIDAE: Swans, Geese, and Ducks

Whistling Swan (*Olor columbianus*)

Status: Regular migrant, two summer records.

Migration: Common to locally abundant spring migrant in the Western Upland, fairly common in the Central Plain and uncommon in the Northern Highland. Spring migrants arrive about 25 March in the Western Upland and by 15 April in the Northern Highland. Peak spring migration occurs 10–25 April. During this period, flocks of 300 to 400 birds are frequently observed, primarily on the prairie wetlands of St. Croix and Washington counties. Roberts (1932) cited the passage of about 2,000 whistling swans through the Valley during "the spring of 1923." Departure is very rapid; most birds are gone by 10 May (latest—13 May 1975, Burnett County).

Fall migration begins with the arrival of the first birds in the Northern Highland about 5 October. Small groups of swans slowly move into the region during most of October. Peak fall migration occurs 25 October to 15 November. Currently, peak concentrations range from 100 to 300 individuals. Roberts (1932) described the observation of "several mixed flocks of swans and geese, one numbering 1,200 to 1,500 birds" at Stillwater. Dates of peak numbers vary considerably and are dependent upon the advancement of northern cold fronts. Departure from the region usually occurs by 1 December and is dependent upon the amount of ice formed on area waters.

Summer: A lone whistling swan was observed at Crex Meadows, Burnett County, on 26 June 1957 (Lound and Lound 1957*d*). A single bird remained in St. Croix County during the 1979 summer (Tessen 1979*b*). Both birds were probably injured.

Habitat: Migrant whistling swans utilize a variety of wetland types during migration. In spring, whistling swans are usually found feeding in numerous temporarily flooded wetlands which are fertile. Larger semipermanently and permanently flooded wetlands are used in spring, primarily as roosting sites. During fall migration swans utilize the larger permanently flooded wetlands and open riverine habitats.

Canada Goose (*Branta canadensis*)

Status: Regular migrant and nesting species, casual winter resident.

Migration: Common to locally abundant migrant throughout the region, especially numerous along the St. Croix River and in central St. Croix, Washington, and southern Burnett counties. Arrival of the first spring migrants in the Western Upland occurs 20–25 February and they have reached the Northern Highland (Burnett County) by 10 March. Peak spring migration occurs 25 March to 20 April. Largest numbers of migrants usually occur at the Crex Meadows Wildlife Area, Burnett County.

Fall migration begins about 1 September with the formation of loose ocks among local breeding birds. A gradual influx of migrants adds to the opulation, and peak fall migration occurs 15 October to 5 November. The rgest concentration on record is 8,000 at Crex Meadows on 31 October 970. The fall population rapidly declines after the peak and most birds have eparted by 10 December.

esting Season Distribution: Currently a fairly common nesting species hroughout the region, common at Crex Meadows. The success of the anada goose as a nesting bird is related to the reestablishment of breeding dult giant Canada geese (*B. c. maxima*) at Afton, Washington County, and t Crex Meadows. A captive flock was established at Crex Meadows in 1957, nd the first young were produced in the wild in 1960. This flock steadily creased and now over 100 pairs produce 300 young annually (WDNR files).

The Afton flock was established in 1960 and resulted in movement of reeding birds into nearby wetlands of Washington, Polk, and St. Croix ounties. Canada geese were first recorded summering in St. Croix county in 961 and nesting was recorded in 1963. Establishment of free-flying flocks f Canada geese was very popular in east central Minnesota and western Visconsin throughout the 1960's and early 1970's. Many of these releases ere successful and now several hundred breeding pairs return to the Valley ch spring.

Vinter: Casual winter resident in the Western Upland, primarily associated ith the St. Croix River. Nearby agricultural fields are typically used for eding during winter.

abitat: Canada geese are usually found nesting on semipermanently and ermanently flooded wetlands in the Western Upland. Many goose nests are und on old muskrat houses in these wetlands. At Crex Meadows, nesting anada geese typically use large man-made impoundments.

rant (*Branta bernicla*)

tatus: Accidental, three fall records.

ecords: A flock of three birds clearly identifiable to this species was ob- erved at Crex Meadows, Burnett County, on 2 October 1954 (N. R. Stone). group of 10 brant was observed at Crex Meadows on 6 October 1974 . H. Dueholm). N. R. Stone observed a brant referable to the Pacific sub- ecies (*B. bernicla nigricans*) on 31 October 1959 at Crex Meadows. The ird was observed from 120 m; the neck markings were present and the lack underwing coverts were noted, distinguishing this bird from the east- rn race.

Vhite-fronted Goose (*Anser albifrons*)

tatus: Regular migrant.

igration: Rare spring migrant, with records from Burnett, St. Croix, and Vashington counties. Arrival dates do not demonstrate any pattern, ranging from 3 April 1968 and 8 April 1971 in Burnett County and 26 March 1976 in St. Croix County, to 12 April 1971 in Washington County. Most records occur during 5–20 May; the latest record was 2 June 1961 at Crex Meadows, Burnett County.

Rare fall migrant with records only from Burnett and St. Croix counties. Fall dates range from 16 September to 10 November 1964 (Crex Meadows). Most records are from 5–20 October. White-fronted geese are usually observed in fall in flocks of three to six. The largest flock recorded (12) was observed in St. Croix County on 28 March 1978.

Habitat: Spring migrants are usually observed on temporarily or semipermanently flooded wetlands. During fall migration most observations consist of birds in feeding flocks with other geese in corn or oat stubble fields.

Snow Goose (*Chen caerulescens*)

Status: Regular migrant, accidental in summer and winter.

Migration: Rare spring and fairly common fall migrant throughout the Valley; locally common at Crex Meadows, Burnett County, during fall migration. Spring migration begins with the arrival of small scattered flocks 5–15 April (earliest—16 March 1966, Washington County). No large populations occur during spring migration and most birds depart by 15 May (latest—3 June 1977, St. Croix County). Fall migrants arrive about 20 September (earliest—13 September 1974, Burnett County). Peak fall populations usually consist of groups totaling 200 to 300 individuals per county. Occasionally, exceptionally large concentrations occur at Crex Meadows Wildlife Area, including 11,650 on 2 November 1971 (WDNR files). Normal peak fall populations occur 15 October to 1 November and departure by 20 November.

Summer: N. R. Stone recorded a blue phase snow goose in molt in Black Brook Township, Polk County, on 20 June 1951. Another blue phase goose was recorded at Crex Meadows, Burnett County, on 7 July 1953.

Winter: P. D. Tweet observed a flock of six in Troy Township, St. Croix County, on 1 January 1977. These birds were probably late migrants.

Habitat: Primary habitat use of migrant snow geese consists of temporarily or semipermanently flooded wetlands. Adjacent agricultural fields, both row crops and hay, are heavily used for feeding.

Mallard (*Anas platyrhynchos*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Common to locally abundant spring migrant in the Western Upland and Central Plain, fairly common to locally abundant in the Northern Highland. Determination of spring arrival dates is compounded by the presence of wintering birds. Movements of birds into the region are observed in late February with increases along the St. Croix River. Birds gradually move north arriving in the Northern Highland about 15 March. Peak spring opulations occur 5–15 April; 6,000 to 8,000 birds are commonly observed in t. Croix County. Movement of nonbreeding mallards is rapid after peak eriods; departure is by 1 May.

Fall migration begins 1–10 September with formation of local feeding ocks of adults and juveniles. Movements of migrants into the region begins bout 20 September; peak populations occur 20 October to 1 November. oncentrations at Crex Meadows, Burnett County, have surpassed 11,000 wice (11,500 on 30 October 1967 and 15,000 on 3 November 1964). ecently, use of two refuges in St. Croix County has resulted in large num- ers of mallards exceeding 10,000 (largest, 13,500 on 20 October 1977). ovement from the region is dependent on weather conditions. Departure of he largest number of birds occurs by 20 November and those not wintering ave departed by 15 December.

esting Season Distribution: Common breeding duck throughout the egion; nesting has been reported from all counties. Most research has cen- ered on breeding populations in the pothole region of St. Croix and southern olk counties, and at Crex Meadows. In the former area, Peterson (1978) stimated a breeding population of mallards of nearly 1.4 pairs per km^2. At rex Meadows, the estimated number of mallard breeding pairs on water- owl survey transects ranged from 7 in 1973 to 55 in 1977 (WDNR files).

inter: Common wintering duck wherever open water is available. Large arly winter flocks are usually associated with open water areas along the t. Croix River. Cooper and Johnson (1977) reported that 75 to 200 mallards intered near Afton, Washington County, from 1974 to 1977. Substantial intering populations are also known to occur along the Kinnickinnic River n Pierce County and southern St. Croix County.

abitat: Nesting mallards occupy a variety of wetland classes ranging from edge meadows and acidic bogs to permanently flooded wetlands. Nesting airs also use lowland forest habitat along rivers and streams, man-made npoundments, and stock-watering ponds created by the Soil Conservation ervice. With the almost complete destruction of native grassland habitat, hese ducks now commonly nest in haylands and oat and corn fields. Several housand acres of Managed Grasslands have been established by govern- ent agencies to provide dense waterfowl nesting cover.

lack Duck (*Anas rubripes*)

tatus: Regular migrant, nesting species, and winter resident.

igration: Uncommon spring migrant in all regions; fairly common in the all in the Northern Highland and locally at the Crex Meadows Wildlife rea, Burnett County. Spring migrants arrive along the St. Croix River bout 15 March, generally moving to natural basin wetlands 1–10 April. No eak spring concentrations of black ducks have been noted, although they re most frequently observed 10–25 April. Departure from nonbreeding reas usually occurs by 15 May. Stragglers have been noted during late May nd throughout the summer, primarily in the Western Upland.

Fall migrants arrive in the Western Upland 5–10 September. Peak fall populations occur 20 October to 10 November. Largest concentrations have been noted at the Crex Meadows Wildlife Area, Burnett County; 1,000 individuals were recorded 14 November 1964, 7 November 1965, and 28 October 1966. In the Western Upland, greatest numbers occur in central St. Croix County and along the St. Croix River and backwaters 25 October to 5 November. During fall migration, black ducks are usually observed in close association with flocks of mallards. Departure during fall occurs 15 November to 1 December, depending on weather conditions.

Nesting Season Distribution: Locally occurring nesting duck, primarily in the Northern Highland. Green and Janssen (1975) have mapped the breeding distribution of this duck in Minnesota and indicated it as a regular nesting bird in northern Pine County. There are two Washington County nest records: 24 May 1971, a female with 10 young was observed near Hugo, Minnesota, and nesting was reported during the summer of 1978 (Green 1979). Pair counts at Crex Meadows from 1957 to 1976 revealed an average of 1.1 pairs per year; broods were observed in 1957 and 1971 (WDNR files). Jackson (1941) observed one black duck near Solon Springs, Douglas County, on 8 August 1919. In St. Croix County, one pair was observed near New Richmond on 28 June 1975. They may have been nonbreeding birds or late migrants.

Winter: Fairly common winter resident wherever there is open water. Recorded primarily along the lower St. Croix River (Hudson-Stillwater) and below the dam at Taylors Falls. One midwinter record for Crex Meadows, Burnett County, 12 January 1955.

Habitat: The black duck is primarily a species of northern forested wetlands. Typical habitat consists of 0.5 ha or larger permanently flooded wetlands that are slightly acidic. Pairs and broods have also been noted on acid bog wetlands and beaver ponds.

Gadwall (*Anas strepera*)

Status: Regular migrant and nesting species, casual winter resident.

Migration: Uncommon migrant in the Western Upland and Central Plain; uncommon to rare in the Northern Highland except at Crex Meadows. Spring migrants arrive 25 March to 5 April in the Western Upland, reaching the Northern Highland 10–15 April (earliest—31 March 1958, Burnett County). Peak spring migration occurs 15–25 April and departure of nonbreeders occurs 5–15 May.

Fall migrants arrive 20–30 September reaching peak numbers 10–15 October. The largest concentration recorded at Crex Meadows, Burnett County, was 400 on 3 October 1970, and the largest number on the St. Croix County wetlands was 150 on 10 October 1975. Departure of fall migrants occurs after mid-October and most birds have left by 10 November.

Nesting Season Distribution: Rare and local nesting species with confirmed brood records from St. Croix, Polk, and Burnett counties. Gadwalls were released at the Crex Meadows Wildlife Area, Burnett County, during 1970 in an attempt to establish this prairie duck on seeded native prairie grasslands.

his release met with limited success because the first brood was not oberved until 1974. In the prairie wetlands of southern Polk and central St. roix counties, gadwalls occur as a rare nesting species in a narrow band beween Roberts (St. Croix County) and Alden Township (Polk County).

inter: One bird was recorded on the Afton CBC in St. Croix County on January 1973.

abitat: Nesting gadwalls at Crex Meadows are generally associated with an-made potholes constructed to resemble natural basin wetlands. In St. roix and southern Polk counties, breeding pairs are typically associated ith seasonally and semipermanently flooded wetlands. Vegetation of these etlands is composed of cattail, bulrushes, and various other emergent pecies.

intail (*Anas acuta*)

tatus: Regular migrant and nesting species, one winter record.

igration: Fairly common spring migrant in the Western Upland and entral Plain, uncommon and local in the Northern Highland. Pintails are mong the first dabbling ducks to arrive in the region, usually 5–15 March. eak spring populations occur 10–20 April, and depart by 15 May. Goddard 975) found that pintails made up 0.9% of the spring migrant waterfowl in t. Croix County and 2.8% of the migrant dabbling duck population.

Fall migrants arrive in late August. During the fall, pintails are fairly comon at Crex Meadows, Burnett County, in central St. Croix, and eastern ashington counties, and in southern Polk County. They are rare and local other regions during this period. Peak fall populations occur 25 Septemer to 10 October and departure occurs by 15 November. Largest fall poputions at Crex Meadows have been 400 birds reported on 4 October 1956, 9 September 1964, and 27 September 1973.

esting Season Distribution: Uncommon and local nesting species with recrds from Washington (Green and Janssen 1975), St. Croix, Polk, and Burett counties. In central St. Croix and southern Polk counties, pintails made p 0.8% of the breeding duck population (Peterson 1978). At Crex Meadows, aterfowl pair counts indicated that pintails constituted about 1% of the early breeding population from 1957–78 (WDNR files).

inter: One pintail was observed on the St. Croix River, Burnett County, on 2 and 13 January 1949 (Robbins 1949). Afton CBC data include single pinils on 1 January 1972 and 1973, and two birds on 1 January 1974, 1976, nd 1978.

abitat: Nesting pintails are typically associated with seasonally and semiermanently flooded wetlands that support a lush growth of emergent quatic vegetation.

reen-winged Teal (*Anas crecca*)

tatus: Regular migrant and nesting species, two winter records.

Migration: Fairly common migrant in all regions, locally common during spring in the Western Upland. Spring migrants begin to arrive in the Western Upland 25 March to 1 April (earliest—15 March, St. Croix County). Arrival in the Northern Highland occurs 5–10 April. Peak spring populations occur 15–25 April and departure of nonbreeding birds occurs by 15 May. In St. Croix County, Goddard (1975) found that green-winged teal made up 4.6% of the spring waterfowl population and 13.6% of the dabbling ducks.

Fall migration begins about 25 August with a slow increase of numbers in the Central Plain and Northern Highland. Peak populations occur 1–15 October in the Northern Highland. The largest population recorded at Crex Meadows, Burnett County, was 600 birds on 2 October 1971. Peak fall populations in the Western Upland occur 10–25 October. Although departure is fairly slow, most green-winged teal have departed by 15 November.

Nesting Season Distribution: Uncommon to rare nesting species throughout the Valley. Most observations of birds during this period are made in the prairie wetland region of St. Croix, Polk, and Washington counties, and at Crex Meadows. Green-winged teal are the fourth most common breeding duck at Crex Meadows (WDNR files). In St. Croix and Polk counties, green-winged teal constitute about 0.4% of the breeding waterfowl population.

Winter: One bird was observed on the Afton CBC on 1 January 1972. N. R. Stone observed three birds at Clam Lake, Burnett County, on 13 February 1950 (Robbins 1950*a*).

Habitat: Pairs and broods are associated with seasonally and semipermanently flooded wetlands. Of seven green-winged teal nests that I located in St. Croix County in 1976, all were in alfalfa fields.

Blue-winged Teal (*Anas discors*)

Status: Regular migrant and nesting species.

Migration: Abundant migrant in the Western Upland, common in the Central Plain, and fairly common (locally common) in the Northern Highland. Goddard (1975) found that blue-winged teal made up 14.4% of all waterfowl and 43% of all dabbling ducks using St. Croix County wetlands in spring.

Blue-winged teal are among the last migrant ducks to arrive in spring; average arrival date is 5 April (earliest—23 March 1976, St. Croix County). Populations build rapidly and peak numbers are usually noted 20 April to 10 May. The first migrants usually arrive in the Northern Highlands about 20 April and reach peak populations 5–15 May.

Fall migrants begin to form large feeding aggregations in late July and early August. Peak fall populations occur early; the largest number (1,200) observed at Crex Meadows, Burnett County, was on 17 September 1976. Typically, large numbers of blue-winged teal are observed 10–25 September in St. Croix and Washington counties (1,000 on 23 September 1975). Departure from the region is very rapid after peak populations occur, and most irds are gone by 20 October (latest—2 December 1973, Washington ounty).

esting Season Distribution: Abundant nesting duck on prairie wetlands of t. Croix, Polk, and Washington counties. Preliminary data collected by the /DNR (Peterson 1978) show a breeding density of about 1.7 pairs per km² ı St. Croix and Polk counties. At Crex Meadows, blue-winged teal are the ıost abundant breeding duck, averaging nearly 42% of all breeding pairs bserved from 1957–78 (WDNR files).

labitat: Blue-winged teal use a wide variety of wetland types for nesting, ınging from sedge meadows to bog wetlands. Largest densities occur on easonally, semipermanently, and permanently flooded wetlands containing n abundance of submerged and emergent aquatic vegetation. To a lesser xtent, breeding pairs also use stock ponds and dugout ponds created by the oil Conservation Service. Lowland Deciduous Forest habitat along streams nd rivers is regularly used.

innamon Teal (*Anas cyanoptera*)

tatus: Casual spring and fall migrant.

ecords: Cinnamon teal have been observed four times at Crex Meadows, urnett County: 14 April 1953 (six birds); 25 April 1955 (two); 8 May 1956. lunt and Jahn (1968) observed a male cinnamon teal at Crex Meadows on 1 April 1968. One bird was observed in Washington County on 16 April 963 (Honetschlager 1963). Roberts (1932) cited the collection of a male innamon teal near Stacy, Chisago County, "sometime between October 5-5, 1923." A second male was obtained "at almost identically the same lace" on 15 September 1924.

merican Wigeon (*Anas americana*)

tatus: Regular migrant and casual nesting species.

ligration: Fairly common migrant in the Western Upland; uncommon in he Central Plain and Northern Highland. Goddard (1975) found that American wigeon made up 2.2% of all waterfowl and 4.5% of the dabbling ducks sing St. Croix County wetlands during spring migration.

Spring migrants arrive in the Western Upland 20–30 March; the earliest irds occur along the St. Croix River. Arrival is somewhat later at Crex leadows, Burnett County, where the average arrival is 8 April. Movement ıto the Valley is very rapid and peak populations are usually observed 0–25 April. Departure from the Valley usually occurs 10–25 May.

Fall migrants arrive in late August and build up rapidly, reaching peak opulations 25 September to 10 October. The largest number observed at rex Meadows (400) occurred on 3 October 1970. In St. Croix County, fall eak populations of 200 to 300 birds are common and 720 were observed on October 1976. Departure from the Valley occurs 1–10 November (latest—5 December 1974, Washington County).

Nesting Season Distribution: Nest records of American wigeon have been confirmed only at Crex Meadows: two broods (eight each) in July 1967 (first brood observed on 14 July); one brood observed in 1970 and 1971; one brood of four observed on 21 July 1975, and two broods during 1976. Elsewhere, summering pairs are regularly observed in St. Croix and Polk counties. The only evidence suggestive of nesting was a female acting "broody" on a pond 1.6 km northwest of New Richmond on 20 July 1977. Although summering pairs are regularly observed in Washington County near Lake Elmo, no evidence of nesting has been obtained.

Habitat: Breeding pairs at Crex Meadows are typically associated with large man-made impoundments. In St. Croix and Washington counties summering American wigeon pairs are associated with semipermanently flooded wetlands.

Northern Shoveler (*Anas clypeata*)

Status: Regular migrant and nesting species.

Migration: Fairly common spring migrant in the Western Upland, uncommon to rare elsewhere. Rare throughout the Valley during fall migration. Goddard (1975) found that the northern shoveler made up 2.2% of the waterfowl population and 6.4% of the dabbling duck population in St. Croix County during spring migration.

Spring migrants arrive 1–5 April (earliest—24 March 1976, St. Croix County). Peak spring migration in the Western Upland occurs 20 April to 5 May and departure occurs 15–20 May. Elsewhere, arrival occurs 10–20 April (average 15 April at Crex Meadows). Peak spring populations occur about 10 May and departure by 20 May. Fall migrants begin to arrive 10–20 August. Peak fall populations cannot be determined because of the small number of birds usually observed. Departure from the Valley occurs by 15 November.

Nesting Season Distribution: Regular nesting species at Crex Meadows, Burnett County, where up to eight pairs per year have been recorded on breeding waterfowl survey transects (WDNR files). Elsewhere, northern shovelers are encountered irregularly during the breeding season in St. Croix, southern Polk, and Washington counties.

Habitat: Soft-bottomed semipermanently and permanently flooded wetlands supporting populations of macroinvertebrates are usually occupied during the nesting season. During spring migration, extensive use is made of temporarily flooded wetlands.

Wood Duck (*Aix sponsa*)

Status: Regular migrant and nesting species, casual in early winter.

Migration: Common migrant throughout the Valley. Spring migrants arrive in the Western Upland 15–20 March (earliest—6 March 1975, Pierce County). Spring migration progresses according to the opening of river systems and arrival in the Northern Highland occurs 1–10 April. Peak spring migration occurs 15–25 April in the Western Upland and 25 April to 5 May in the Northern Highland. Goddard (1975) reported that wood ducks constituted 0.4% of the total spring waterfowl population and 1.2% of the dabbling duck population on prairie wetlands in St. Croix County. This low percentage is undoubtedly related to their preference for riverine habitats.

Fall migration begins during mid-August with the formation of feeding groups. A gradual buildup in numbers occurs throughout September. Peak populations at Crex Meadows, Burnett County, usually occur 20 September to 5 October; the largest groups were noted on 4 October 1967 (1,500) and 14 September 1968 (1,000). Elsewhere, peak populations occur 1–20 October. Especially important riverine staging areas occur along the Kettle River (Pine County), Apple River (Polk and St. Croix counties), and Willow River (St. Croix County). Departure from the Valley occurs rapidly after mid-October; the latest dates were 20 November 1976 and 20 December 1956 (both Washington County).

Nesting Season Distribution: Uncommon to fairly common nesting species in all regions. Nesting records exist for all counties and nesting birds are numerous along the larger tributaries of the St. Croix River. In St. Croix County, the wood duck ranks third in abundance behind mallard and blue-winged teal as a breeding duck (B. A. Moss, personal communication).

Winter: Winter records include 1 January 1972 and 1973 (Afton CBC, Washington County); 27 December 1970 (Solon Springs CBC, Douglas County); and 20 January 1975 (McKenzie Creek, Polk County).

Habitat: Primary habitat use by nesting wood ducks includes wooded streams, rivers, backwater sloughs, and wooded lakes. In the Northern Highland, breeding pairs also use tamarack bogs and spruce-lined lakes. In the Western Upland, use of prairie wetlands has been enhanced by the placement of artificial nest boxes.

Redhead (*Aythya americana*)

Status: Regular migrant and casual nesting species.

Migration: Fairly common migrant in the Western Upland, particularly in western St. Croix and eastern Washington counties. Uncommon to rare elsewhere, especially in the Northern Highland. Spring migrants arrive in the Western Upland 5–10 April (earliest—23 March, St. Croix County). Peak abundance occurs 25 April to 5 May and most have departed by 25 May. Goddard (1975) found that redheads made up 2% of the total spring waterfowl population and 4.5% of the spring diving duck population in St. Croix County. At the Crex Meadows Wildlife Area, Burnett County, the average date of spring arrival is 15 April; peak populations occur 1–10 May, and departure by 1 June.

Fall migrants begin to arrive 10–20 September. Populations build slowly through October, reaching largest numbers 20 October to 1 November. The principal fall migration route used by redheads is south of the Valley. Because of this, concentrations larger than 50 birds are rarely encountered during fall migration. Departure from the region occurs rapidly after 15 November; occasional stragglers linger along open areas of the St. Croix River until 1 December.

Nesting Season Distribution: There are six breeding records for the Valley: a female with a brood of four on West Twin Lake, St. Croix County, 1968 (J. T. Lokemoen); a female with a brood of four on East Twin Lake, St. Croix County, 1975 (B. A. Moss); females with broods of five and six on the Gust Waterfowl Production Area, St. Croix County, 1976 and 1977 (C. A. Faanes); two broods of six and seven on Oakridge Lake during July 1976. Elsewhere, occasional summering pairs have been observed in central Washington and southern Polk counties, although no broods have been observed. At Crex Meadows, summering pairs are noted almost yearly, although the only suggestion of nesting was a female acting "broody" on 16 June 1975 (S. D. Robbins, personal communication).

Habitat: All redhead broods have been observed on large permanently flooded wetlands where the dominant emergent vegetation consists of cattail and river bulrush.

Ring-necked Duck (*Aythya collaris*)

Status: Regular migrant and nesting species, casual in winter.

Migration: Abundant migrant throughout the Valley. Spring migrants arrive in the Western Upland about 15 March and the Northern Highland 1–5 April (earliest—20 March 1950, Burnett County). Peak populations of spring migrants occur 20 April to 1 May. Goddard (1975) found that ring-necked ducks were the second most abundant spring migrant duck in St. Croix County, making up 14.8% of the total waterfowl population and 32.8% of the diving duck population. Departure from nonbreeding areas occurs by 20 May.

Fall migrants begin to form flocks in the Northern Highland in mid-September and the first migrants reach the Western Upland about 25 September. Peak fall populations at Crex Meadows, Burnett County, usually occur 20–30 October and have included 5,000 (25 October 1967), 5,500 (25 October 1965), and 7,500 (26 October 1966). In the Western Upland, peak populations occur about 1 November and include up to 1,500 birds (B. A. Moss, personal communication). Departure from the Valley occurs steadily through November with stragglers occurring along the St. Croix River until 1 December.

Nesting Season Distribution: Uncommon nesting species in the Western Upland; fairly common in the Central Plain and Northern Highland, common at Crex Meadows. Breeding records have been obtained in all counties except Pierce and the breeding range includes the area north of Marine-on-St. Croix and New Richmond.

Breeding waterfowl surveys at Crex Meadows reveal that the ring-necked duck is the third most numerous nesting species (WDNR files). In St. Croix and southern Polk counties, Peterson (1978) found that ring-necked ducks constituted an insignificant percentage of the breeding population. How-ver, most ring-necked duck breeding activity in St. Croix and Polk counties ccurs west and north of Peterson's study area.

Vinter: One male was observed on the Afton CBC 1 January 1975.

Iabitat: Ring-necked ducks are primarily a species of permanently flooded etlands in the forested areas of the Valley. Typical brood habitat consists f slightly acidic water and scattered growths of pond lily, bulrush, and cat- ail. Beaver ponds are commonly used in the northern counties and acid bogs re occasionally used.

anvasback (*Aythya valisineria*)

tatus: Regular migrant and casual summer resident, one nesting record nd one winter record.

Iigration: Uncommon spring and fall migrant in the Western Upland and entral Plain, rare in the Northern Highland. Spring migrants arrive in late Iarch (earliest—16 March). Peak abundance occurs 10–25 April and depar- ure occurs 10–20 May .Goddard (1975) found that the canvasback made up .4% of the total spring waterfowl population and 1.0% of the diving duck opulation in St. Croix County. Fall migration begins in mid-September ith arrival of small flocks on the larger lakes and the St. Croix River. Peak all populations occur 15 October to 1 November and departure by 30 No- ember.

Iesting Season Distribution: Casual summer resident in St. Croix County nd at Crex Meadows, Burnett County. The only nesting record is my obser- ation of a hen with a brood of eight on Oakridge Lake, St. Croix County, on July 1976. Summering pairs are occasionally observed on other prairie etlands although no evidence of nesting is available. Elsewhere, summer- ng pairs were observed at Crex Meadows in 1950, 1962, 1975, and 1978.

Vinter: A male canvasback was observed on the Afton CBC, Washington ounty, on 1 January 1975.

Iabitat: The nesting record was obtained on a large permanently flooded etland. Dominant vegetation included softstem bulrush, cattail, and river ulrush. Most additional summer records are the birds on semi-open perma- ent wetlands. During migration, canvasbacks utilize most wetland types, lthough a preference is shown for semipermanently and permanently looded wetlands.

reater Scaup (*Aythya marila*)

tatus: Regular migrant.

Iigration: Rare migrant throughout the Valley. Spring migrants arrive -15 April and are most regularly observed 25 April to 5 May. First nigrants are usually observed on the St. Croix River, followed by an in- rease of observations away from the river. Departure from the Valley ccurs by 15 May (latest—29 May 1968, Burnett County). Goddard (1975) ailed to record the greater scaup during four spring field seasons in St.

Croix County.

Fall migrants occur 5 October to 20 November; most records are 20 October to 5 November. Fall migrants are usually observed intermixed with large rafts of lesser scaup, whereas in spring migration, greater scaup seem to be more segregated from lesser scaup.

Habitat: Large, open permanently flooded wetlands typically support the most greater scaup in this region. Cedar Lake on the Polk–St. Croix County line is probably the most productive lake in the region for observing greater scaup.

Lesser Scaup (*Aythya affinis*)

Status: Regular migrant, casual nesting species, and occasional in early winter.

Migration: Abundant migrant throughout the Valley. The lesser scaup is the most numerous migrant duck in the Valley. In St. Croix County, Goddard (1975) found that lesser scaup made up 24.6% of the total spring waterfowl population and 54.6% of the diving duck population. Spring migrants arrive in the Western Upland 10–15 March (earliest—6 March 1976, Washington County) and the Northern Highland 1–10 April. Peak spring populations occur 20 April to 10 May when flocks of 700 to 1,000 individuals are typically observed on larger lakes. Departure occurs 20–30 May.

Fall migrants arrive 20 September to 1 October. Fall migration is characterized by a rather low increase in numbers until about 20 October when large influxes occur. Peak fall populations at Crex Meadows Wildlife Area, Burnett County, occur 25 October to 5 November and have totaled up to 7,000 individuals (30 October 1965). In the Western Upland, peak fall populations larger than 3,000 individuals are observed 25 October to 5 November. Departure from the Valley is dependent on ice conditions on larger lakes; most birds depart by 1 December.

Nesting Season Distribution: Regular summer resident on wetlands in Polk, St. Croix, and central Washington counties. Usually up to 10 pairs can be found on wetlands near New Richmond, St. Croix County. There are two brood records for the Valley; both broods were found on 7 July 1976, on wetlands in Alden Township, Polk County. These broods were within 0.8 km of each other and constituted the eighth and ninth, 20th century breeding records for Wisconsin. At Crex Meadows, 10 pairs were observed during 1958. Since then at least one pair has been present yearly; however, no broods have been observed. Jackson (1942) reported the collection of a male lesser scaup on Upper St. Croix Lake, Douglas County, on 1 August 1919.

Winter: Occasional early winter visitor primarily on open stretches of rivers. These birds are probably late fall migrants rather than wintering birds because no midwinter records exist. Dates range from 22 December 1956 to 1 January 1973, 1975, 1976 (Afton CBC); 29 December 1973 to 3 January 1976 (Suburban St. Paul CBC); 12–13 January 1949, 12 January 1955, 9 January 1956, and 7 January 1957 (Crex Meadows); 31 January 1949, St. Croix Falls (Polk County); and 23 December 1975, Solon Springs CBC

Douglas County).

Habitat: The Polk County broods were observed on semipermanently looded wetlands. Dominant vegetation included cattail, burreed, and coon-ail. Most summering pairs are observed on small semipermanent wetlands.

Common Goldeneye (*Bucephala clangula*)

Status: Regular migrant and winter resident, one summer record.

Migration: Common migrant throughout the Valley, most numerous along he St. Croix River and on large lakes of the Northern Highland. Fall migrants arrive in the Northern Highland 20 September to 1 October and each the Western Upland 10–20 October. Peak fall common goldeneye populations occur 10–30 November.

Spring migrants reach peak abundance 10 March to 1 April and most have eparted by 1 May (latest—30 May 1967, Burnett County). Movement of pring migrants is similar to fall; most birds use rivers and large lakes. Goddard (1975) found that common goldeneyes on prairie wetlands made up <1% of the total spring waterfowl population; his 4-year observations otaled 707 individuals. On the St. Croix River <16 km from Goddard's tudy area, daily totals in excess of 100 individuals were recorded on March 1975, 11 March 1977, and 9 April 1978. Yearly totals in excess of ,000 individuals along the St. Croix River were regularly recorded from 972 to 1978.

Winter: Common winter resident wherever open water is present. Primary intering populations occur at the confluence of the St. Croix and Mississippi Rivers at Prescott, Wisconsin (150 to 200 individuals); below the Alan . King generating plant at Bayport (Washington County); near Hudson 25 on 1974 Afton CBC and 360 on 1975 Afton CBC); and below the electric enerating dam at St. Croix Falls–Taylors Falls (50 to 100 individuals).

ummer: S. D. Robbins observed a lone male throughout the summer of 967 in St. Croix County.

Habitat: Large open stretches of rivers that apparently support healthy opulations of fishes and invertebrates. During migration, common goldeneyes are typically associated with large (> 20 ha) permanent lakes.

Barrow's Goldeneye (*Bucephala islandica*)

tatus: Accidental, two records.

ecords: Faanes and Goddard (1976) cited one observation from East Twin ake, St. Croix County, on 8 May 1975. M. R. Olson observed one male long Trout Brook Road near Hudson, St. Croix County, on 1 January 1977. he bird was observed again on 2 January 1977 on the St. Croix River.

ufflehead (*Bucephala albeola*)

tatus: Regular migrant, one summer and one winter record.

Migration: Fairly common migrant in the Western Upland and Central Plain; common on forested lakes in the Northern Highland. Goddard (1975) found that buffleheads constituted 1.6% of the total spring waterfowl population and 3.5% of the diving duck population on prairie wetlands in central St. Croix County.

Spring migrants arrive in the Western Upland 20 March to 1 April (earliest—13 March 1966, Washington County) and peak populations occur about 20 April. Migrants arrive in the Northern Highland 1–10 April, reaching peak numbers 15–25 April. Departure from the Valley occurs by 25 May. Fall migrants arrive in the Northern Highland about 1 October and the Western Upland about 5 October. Peak fall populations occur 20 October to 1 November and departure occurs by 25 November. Peak fall populations on central St. Croix County wetlands usually total 150 to 200 individuals.

Summer: S. D. Robbins observed a lone bufflehead at Crex Meadows, Burnett County, on 17 June 1976. This may have been an injured bird.

Winter: A flock of 40 buffleheads was observed on the St. Croix River near Grantsburg, Burnett County, from 12–13 January 1949 (Robbins 1949).

Habitat: Buffleheads are associated with a variety of wetland types during spring migration, including temporarily, seasonally, and permanently flooded wetlands, and riverine habitats. During fall migration buffleheads are usually associated with large semipermanently and permanently flooded wetlands.

Oldsquaw (*Clangula hyemalis*)

Status: Casual, five records.

Records: Oldsquaw were observed on Oakridge Lake near New Richmond, St. Croix County, on 24 October 1974 (S. R. Schneider); 14 October 1975 (R. E. Faanes); and 2 October 1977 (C. A. Faanes). One was observed at Crex Meadows Wildlife Area, Burnett County, on 22 April 1952 (Strelitzer 1952). In Washington County, three birds were observed on 6 January 1965.

Common Eider (*Somateria mollissima*)

Status: Accidental, one record.

Record: One female common eider was shot on Phantom Lake, Crex Meadows Wildlife Area, Burnett County, on 10 November 1968 (Tessen 1969*b*).

White-winged Scoter (*Melanitta deglandi*)

Status: Casual, four records.

Records: N. R. Stone observed one at Crex Meadows, Burnett County, on 8 May 1950 (Robbins 1950*b*), and R. Brown observed one there on 12 August 1975. C. A. Faanes and W. Norling observed a female on Oakridge

Lake, St. Croix County, on 18 October 1974. I observed a female at Amery, Polk County, on 9 November 1976.

Surf Scoter (*Melanitta perspicillata*)

Status: Casual, three records.

Records: A single surf scoter was observed at Crex Meadows Wildlife Area, Burnett County, on 5 October 1974. On 6 October 1974, two birds were shot from a group of four at Crex Meadows by J. O. Evrard. Photos were taken of the two birds. B. A. Moss observed a flock of six surf scoters on Deer Lake, Polk County, on 30 October 1975.

Black Scoter (*Melanitta nigra*)

Status: Casual, two records.

Records: A female black scoter was observed on West Twin Lake near Roberts, St. Croix County, on 18 October 1974 (Faanes and Goddard 1976). On 1 January 1977, I observed a female black scoter with a group of black ducks and mallards at the mouth of the Kinnickinnic River, Pierce County (Lien and Lien 1977).

Ruddy Duck (*Oxyura jamaicensis*)

Status: Regular migrant and nesting species, accidental in winter.

Migration: Fairly common migrant in the Western Upland and Central Plain, rare and local in the Northern Highland. Goddard (1975) reported that ruddy ducks constituted 1% of the total spring waterfowl population and 2.2% of the diving duck population in St. Croix County. Ruddy ducks are the latest arriving waterfowl species in spring. The average arrival date is 10 April in St. Croix County and 25 April at Crex Meadows, Burnett County (earliest dates—24 March 1976, St. Croix County and 4 April 1948, Burnett County). Peak spring populations in St. Croix, Polk, and Washington counties occur 25 April to 10 May; departure of nonbreeding birds is by 20 May. Fall migration begins in early September and peak numbers occur 25 September to 15 October. The largest groups recorded during fall migration range from 25 to 30 birds per wetland. Departure from this region occurs by 1 November (latest—27 November 1967, Washington County).

Nesting Season Distribution: Uncommon and local breeding duck on prairie wetlands of St. Croix, Polk, and Washington counties. These breeding populations occur in pockets of high density wetlands in the respective counties. Peterson (1978) reported that ruddy ducks made up < 1% of the total breeding duck population in St. Croix and Polk counties. Three brood records have been obtained at Crex Meadows, two in 1973 and one in 1974.

Winter: One ruddy duck was observed on the Afton CBC on 22 December 1956.

Habitat: Ruddy ducks are characteristic of semipermanently and permanently flooded wetlands that are dominated by cattail, hardstem bulrush, and river bulrush. Most wetlands occupied by breeding ruddy ducks vary from 1-3 m deep.

Hooded Merganser (*Lophodytes cucullatus*)

Status: Regular migrant and nesting species, two winter records.

Migration: Uncommon migrant throughout the Valley, fairly common locally along heavily wooded lakes and streams in the Northern Highland. Goddard (1972) reported that hooded mergansers made up 0.2% of the total spring waterfowl population in St. Croix County. This low percentage resulted from censusing prairie wetlands that are not utilized regularly by hooded mergansers. Spring migrants arrive in the Western Upland 1–10 April (earliest—23 March 1968, St. Croix County) and the Northern Highland about 10 April (earliest—14 March 1966, Burnett County). Peak abundance occurs 20 April to 5 May and departure from nonbreeding areas occurs by 15 May. Fall migration begins in early September in the Northern Highland and migrants reach the Western Upland about 15 September. Peak fall populations occur 15 October to 1 November and departure by 20 November. Peak fall populations in western Wisconsin range from 50 to 75 birds on important staging wetlands.

Nesting Season Distribution: Fairly common (and local) breeding duck throughout the Valley. Hooded mergansers make up a small proportion of the breeding population on prairie wetlands where the most intensive surveys have been conducted. Lack of survey work along streams and in wooded lake regions contributes to the poor understanding of their breeding distribution.

Winter: There are two winter records including one bird along the St. Croix River near Grantsburg, Burnett County, on 9 January 1956 and one bird on the Afton CBC on 1 January 1975.

Habitat: In the Western Upland and Central Plain, breeding hooded mergansers use heavily wooded river and stream habitats for breeding. An abundance of dead trees providing natural nesting cavities is an important component of their breeding habitat. In the Northern Highland, breeding birds occupy large forest-bordered lakes and acidic bog-type lakes in addition to riverine habitats.

Common Merganser (*Mergus merganser*)

Status: Regular migrant and winter resident, two summer records.

Migration: Common migrant throughout the Valley. Goddard (1975) reported that common mergansers made up 0.1% of the total spring waterfowl population in St. Croix County. This estimate reflects late dates of censusing, which did not coincide with the peak migration period of this bird, rather than an actual low population. Spring migration begins with a noticeable influx about 20 February. Spring populations build rapidly through March reaching peak numbers 20–30 March and most birds have departed by 30 April. Fall migrants arrive in the Northern Highland 20–30 September and reach the Western Upland about 10 October. Peak fall populations occur 10 November to 1 December and nonwintering birds have departed by 15 December. During peak fall periods, up to 1,000 individuals have been recorded along the lower St. Croix River in Washington County.

Winter: Uncommon winter resident of the lower St. Croix River and along open stretches of water on major tributaries. The largest group recorded on the Afton CBC was 65 birds on 1 January 1958. Winter populations are directly related to the severity of winter weather. During 1974–75, groups of 30 to 35 common mergansers were regularly observed along the St. Croix River through late December and early January. The record cold of 11 January 1975 (–40 °C), froze nearly the entire river system and common mergansers were not observed again until mid-February when the first migrants returned.

Summer: Three common mergansers were observed in Chisago County on 16 June 1975 (Eckert 1976), and a lone male was observed near New Richmond, St. Croix County, on 27 June 1975. These birds undoubtedly were lingering migrants.

Habitat: Primarily a species of large, deep, permanently flooded wetlands and the major rivers of the Valley.

Red-breasted Merganser (*Mergus serrator*)

Status: Regular migrant, two summer and one winter records.

Migration: Fairly common migrant throughout the Valley, occasionally common on larger lakes of the Central Plain. Goddard (1975) reported that red-breasted mergansers made up only 0.3% of the total spring waterfowl population in St. Croix County. This estimate indicates that censuses were concentrated on smaller wetlands and were not conducted to coincide with peak migration.

Spring migrants arrive in the Western Upland about 20 March and reach the Northern Highland 1–10 April. Peak spring migration occurs 10–25 April and departure by 15 May. Fall migrants arrive in the Northern Highland 20–30 September and reach the Western Upland about 10 October. Peak fall populations occur 25 October to 15 November and departure by 10 December. During the peak of fall migration, concentrations of 50 to 75 birds are typically recorded on important staging wetlands.

Summer: A lone female was observed at Crex Meadows, Burnett County, on 1 July 1955. In Washington County an injured bird was observed 24 June 1975 (Eckert 1976).

Winter: A group of four was observed on the St. Croix River on the Afton CBC, 1 January 1975. Five were observed in St. Croix County on 5 January 1942 (Barger 1942).

Habitat: Red-breasted mergansers are characteristic of large, deep-water permanently flooded wetlands and riverine habitats. Occasional small groups of migrants occur on semipermanently flooded wetlands during spring migration.

FAMILY CATHARTIDAE: American Vultures

Turkey Vulture (*Cathartes aura*)

Status: Regular migrant and probable nesting species.

Migration: Fairly common migrant throughout the Valley, becoming common at Crex Meadows during the fall. Spring migrants arrive during the first week of April (earliest—24 March 1963 and 1977, Pierce County). Peak spring migration occurs between 20 April and 1 May and most depart by 15 May. Peak fall migration occurs 15–25 September; departure occurs by 15 October (latest—23 November 1948 and 30 November 1950, Burnett County).

Nesting Season Distribution: Rare to uncommon summer resident throughout the Valley, most regularly observed in the forested regions along the upper St. Croix River. Roberts (1932) reported turkey vultures nesting "along the St. Croix River"; however, he provided no dates or locations. Turkey vultures are regularly observed during the summer between Prescott and Stillwater. This area of extensively wooded bluffs provides excellent breeding habitat for vultures. Although young are observed during late July, no nests have been found.

Habitat: Habitat used by turkey vulture during the nesting season consists of Southern Deciduous Forest occurring on bluffs along the St. Croix River.

FAMILY ACCIPITRIDAE: Hawks and Harriers

Swallow-tailed Kite (*Elanoides forficatus*)

Status: Accidental, one record.

Record: One bird was found dead along Highway 95 near Marine-on-St. Croix, Washington County, on 29 April 1966. The specimen is now in the collection of the Minnesota Museum of Natural History (#23152).

Mississippi Kite (*Ictinia mississippiensis*)

Status: Accidental, one record.

Record: A single bird was observed at Crex Meadows, Burnett County, on 27 May 1976 (Hofslund and Niemi 1977).

Northern Goshawk (*Accipiter gentilis*)

Status: Regular migrant and winter resident, casual nesting species.

Migration: Rare migrant throughout the Valley. Most regularly observed in the forested areas of the Northern Highland and Central Plain, casual in the Western Upland. Fall migrants begin to arrive in mid-September and are most conspicuous from mid-October to mid-December. Spring migration begins in late February with dispersal toward nesting areas. Goshawks are most conspicuous in spring 15 March to 10 April and have departed by 30 April.

Nesting Season Distribution: One nesting record for Burnett County; an adult incubating during May 1973 (W. Norling). A nest at Camp Wilder, Washington County, in 1967, was abandoned because of excessive human activity in the immediate area (Huber 1967). Numerous sight records, primarily from the Northern Highland, indicate that additional nesting records are probable.

Winter: Rare to uncommon winter resident throughout the Valley. Most frequently observed in the heavily forested Northern Highland.

Habitat: The Burnett County nest was in mixed jack pine–oak habitat. Additional nesting season records have been obtained from mature Northern Hardwood Forest, mixed coniferous forest, and jack pine–oak habitat.

Sharp-shinned Hawk (*Accipiter striatus*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Uncommon spring and fairly common fall migrant throughout the Valley. Occasionally 30 to 40 migrant sharp-shinned hawks can be observed per day along the St. Croix River. Spring migration begins in mid-March; largest numbers occur 10–25 April. Most birds have arrived on nesting territories by 10 May. Fall migration begins in mid-August and peak numbers are reached 10 September to 10 October. Most have departed by 15 November.

Nesting Season Distribution: Uncommon to rare during the nesting season in the Central Plain and Northern Highland. Although this hawk is regularly observed during the nesting season, only one nest has been found. On 23 May 1976, I found one sharp-shinned hawk nest in the McKenzie Creek Wildlife Area, Polk County. Other observers, primarily Jackson (1941) and Bernard (1967) have recorded this species during the nesting season but failed to find a nest. In the Minnesota counties, Green and Janssen (1975) stated that during the summer this hawk is "most numerous in the north central, northeastern . . . regions."

Winter: Uncommon to rare winter resident in the Western Upland and Central Plain. Casual in midwinter in the Northern Highland. Three were observed on Solon Springs (Douglas County) CBC on 30 December 1973.

Habitat: The Polk County nest was situated about 4.6 m from the ground in an aspen tree. Surrounding vegetation consisted of young aspen–maple–basswood forest, intermixed with red pine. Additional summer observations have been made in similar habitat and in brushy "edge" situations. This hawk is usually observed in oak–maple woodlots along the St. Croix River during winter. Occasionally, an individual will frequent feeding stations in residential areas.

Cooper's Hawk (*Accipiter cooperii*)

Status: Regular migrant, nesting species, and winter resident. The WDNR has listed this species as threatened (Les 1979). Alteration of nesting habitat resulting from intensive farming is a primary cause for their decline.

Migration: Uncommon to rare migrant throughout the Valley. Spring migration begins in mid-March; birds are most frequently encountered 10–25 April. Nonsummering birds have departed by 15 May. Fall migration begins in late August and continues through mid-October. Because of the low number of birds observed during fall migration, no indication of peak movements is provided.

Nesting Season Distribution: Rare nesting species throughout the Valley. Although this hawk is regularly observed during the summer, only two confirmed nesting records exist. On 13 June 1976 a nest containing two young, and on 29 June 1976 a nest containing one young, were found 8 km west and 4.8 km east of Star Prairie, St. Croix County. Goddard (1972) reported one pair during the breeding season in Pierce County and Jackson (1941) reported a breeding season record (31 May 1919) for Burnett County. Numerous other breeding season records exist, but data on eggs or young are lacking.

Winter: Rare winter resident in the Western Upland; casual to absent elsewhere.

Habitat: Both St. Croix County nests were in second-growth red oak woodlots, bordered by brushy fencerows. I have observed this species during the breeding season in similar second-growth habitats and in mixed jack pine–oak situations in Burnett and Pine counties. Wintering birds are regularly observed occupying Lowland Deciduous Forest habitats during this period. Like the sharp-shinned hawk, this species will occasionally frequent bird feeding stations in residential areas during the winter.

Red-tailed Hawk (*Buteo jamaicensis*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Common (locally abundant) migrant throughout the Valley. During both seasons, large numbers of migrants can be observed associated with the St. Croix River and at Crex Meadows Wildlife Area, Burnett County. Spring migration begins in mid-February in the Western Upland and Central Plain, reaching the Northern Highland about 1 March. Peak spring movements occur 20 March to 15 April, and nonbreeders have departed by 1 May. Fall migration begins in mid-August with dispersal of uveniles from nesting areas. Peak fall movements occur 20 September to 10 October in the Northern Highland and throughout October elsewhere. Nonwintering birds have departed by 1 December.

Nesting Season Distribution: Common nesting species in all regions, most conspicuous in agricultural areas. Nest records have been obtained for all counties except Chisago. Analysis of Breeding Bird Survey data indicate that the red-tailed hawk is the most frequently encountered breeding hawk in the Western Upland and Central Plain.

Winter: Fairly common to uncommon winter resident in the Western Upland. Uncommon to rare in the Central Plain and rare to absent in the Northern Highland. Birds normally depart the northern regions by mid-January. In open agricultural areas along the lower St. Croix River, red-tailed hawks are the most frequently encountered hawk during the winter.

Habitat: Red-tailed hawks use a large variety of habitats during the nesting season. In agricultural areas this hawk will use brushy field margins, small woodlots, and woods edge situations. In the Northern Highland, the species s usually associated with field borders of extensive Northern Deciduous Forest and Coniferous Forest. Jack Pine Barren and Lowland Deciduous Forest probably receive the lowest frequency of use by nesting red-tailed hawks.

Red-shouldered Hawk (*Buteo lineatus*)

Status: Regular migrant, nesting species, and winter resident. The Wisconsin DNR has listed this species as threatened (Les 1979). Habitat destruction is considered the primary reason for their decline.

Migration: Uncommon to rare migrant in the Western Upland and Central Plain; rare to absent in the Northern Highland. Spring migration begins in mid-February with a gradual movement into the Western Upland along the St. Croix River. Migrants have reached the Central Plain by 25 March (earliest—11 March 1950, 16 March 1975; Polk County). Red-shouldered hawk migration is rather diffuse, consisting primarily of movements of solitary ndividuals. Consequently, determination of peak dates is difficult. Most birds have reached nesting territories by mid-April. Fall migration is equally diffuse, consisting of a gradual movement from nesting areas. During fall, ed-shouldered hawks are most conspicuous throughout October and nonwintering birds have departed by 1 December.

Nesting Season Distribution: Uncommon and local nesting species in the Western Upland and Central Plain, rare and local in the Northern Highland. A. C. Rosenwinkel found young in a nest along the Willow River, Pine County, on 7 April 1949 (Mierow 1949). Establishment of the red-shouldered hawk as a nesting bird in the Valley is apparently very recent. Roberts 1932) mentioned no nests from Minnesota, and cited only one summer ecord (3 July 1927, at Marine-on-St. Croix, Washington County). Behavior and plumage of that bird suggested nesting. Since that time, however, the ed-shouldered hawk has been recorded regularly, and there are presently nest records for all the counties except Douglas.

Winter: Rare and local winter resident of Lowland Deciduous Forests in the Western Upland, casual elsewhere.

Habitat: Primarily a species of medium-aged to mature Lowland Deciduous Forest. Rarely encountered away from this habitat type during the breeding season. S. D. Robbins and I recorded one red-shouldered hawk, apparently on territory, in mature black spruce habitat near Range, Polk County, on 16 March 1975.

Broad-winged Hawk (*Buteo platypterus*)

Status: Regular migrant and nesting species.

Migration: Fairly common spring and common fall migrant throughout the Valley. During peak fall migration, broad-winged hawks are occasionally abundant at the Crex Meadows Wildlife Area, Burnett County. Spring migrants arrive in the Western Upland and Central Plain in early April (earliest—26 March 1975, St. Croix County; 24 March 1968, Chisago County). Migrants arrive in the Northern Highland 5–10 April (earliest—21 March 1956, Burnett County). Peak spring migration occurs 15 April to 1 May, and nonbreeders depart by 20 May.

Fall migration begins in late August, with dispersal from nesting areas and formation of loose flocks. Peak fall migration occurs 10–25 September, when 400 to 500 individuals can be observed on good flight days. Movement is very rapid, and departure from the region occurs by 10 October.

Nesting Season Distribution: Common nesting species throughout the Northern Highland and northern tier of the Central Plain. Fairly common in the remainder of the Central Plain. Rare and local in the Western Upland. Nest records exist for all counties of the Valley except Pierce. In the Northern Highland, the broad-winged hawk must be considered the most abundant and conspicuous nesting raptor. Roberts (1932), quoting Surber (1919), stated that along the St. Croix River in Pine County, the broad-winged hawk was "the commonest hawk" in the region.

Habitat: Broad-winged hawks use a variety of coniferous and deciduous forest types for nesting. Regularly used habitats in the Northern Highland and Central Plain include Northern Upland Deciduous Forest, Upland Coniferous Forest, and mixed deciduous–coniferous forest. Jack Pine Barren and jack pine–oak habitats are also occupied, but to a lesser extent. Nesting broad-winged hawks have been found occupying Southern Deciduous Forest and Lowland Deciduous Forest in the Western Upland.

Swainson's Hawk (*Buteo swainsoni*)

Status: Casual migrant throughout the region, regular in St. Croix County. Several recent summer records.

Migration: Rare and local migrant with records from all regions. Spring migration dates range from 3 April 1965 (Burnett County) to 20 May 1967 (Pine County). Most records occur between 20 April and 15 May. Fall migraion records are fewer and range from 6 August 1975 (Burnett County) to 12 October 1968 (Polk County). Most fall migration records occur 25 August to 10 September.

Nesting Season Distribution: During June and July 1978, up to three separate pairs were observed regularly in St. Croix and northern Pierce counties. Specifically, these pairs were near Oakridge Lake and near Erin Corners in St. Croix County, and near the junction of County Highway W and Highway 29, 10 km west of River Falls in Pierce County. Attempts to locate nests failed. These summer records are especially noteworthy because nesting occurs yearly in nearby areas of Dakota County, Minnesota (Green and Janssen 1975).

Habitat: Most Swainson's hawks observed during migration are associated with open habitats including Managed Grasslands and agricultural fields. The birds observed in June and July 1978 were in an ecotone between Managed Grassland and Southern Deciduous Forest. The Pierce County pair was using a hayfield–woods ecotone.

Rough-legged Hawk (*Buteo lagopus*)

Status: Regular migrant and winter resident, accidental in summer.

Migration: Fairly common migrant throughout the Valley, becoming common at Crex Meadows, Burnett County, during the fall and early winter. Fall migrants arrive about 20 September (earliest—4 September 1974, Burnett County; 15 September 1968, Pine County). Peak fall migration occurs 20 October to 15 November, with a gradual exodus from most northerly locations occurring until 1 January. Spring migration begins in late February in the Western Upland and migrants have reached the Northern Highland by 20 March. Peak spring migration occurs 15 March to 15 April and departure by 15 May (latest—7 June 1975, Burnett County; 12 June 1975, St. Croix County).

Winter: Regular winter resident in the Western Upland and Central Plain. Sporadic midwinter resident in the Northern Highland. Distribution and abundance of wintering birds is highly dependent on small mammal populations and the severity of the weather.

Habitat: Rough-legged hawks occupy open habitats almost exclusively. Edges of agricultural fields, hayfields, native grasslands, and wet meadows receive primary use. Occasionally, this hawk will be found in Northern Hardwood and Lowland Deciduous Forests.

Ferruginous Hawk (*Buteo regalis*)

Status: Casual fall visitor.

Records: W. Norling observed an adult at the Fish Lake Wildlife Area, Burnett County, on 25 October 1974. I observed an adult flying over the Oakridge Waterfowl Production Area, St. Croix County, on 24 September 1978. A 30 December 1967 record of a ferruginous hawk on the Suburban St. Paul

CBC is questioned, primarily because of the date and because the only accompanying notes were "all field marks were noted."

Golden Eagle (*Aquila chrysaetos*)

Status: Regular migrant and winter resident.

Migration: Rare migrant throughout the Valley becoming uncommon at Crex Meadows, Burnett County, in the fall. Fall migration begins about 5 October; most records are from 10 October to 15 December (earliest records—3 August 1976, 4 September 1974, and 15 September 1972; Crex Meadows, Burnett County). Peak migration occurs 1 November to 1 December. Spring migration begins in mid-February with a gradual movement through the Valley. Peak migration occurs 1–15 March and departure by 1 April (latest—2 May 1975; Crex Meadows, Burnett County).

Winter: Very rare and local winter resident throughout the Valley. Usually the largest numbers are observed at Crex Meadows, Burnett County, where up to four individuals occur throughout the winter.

Habitat: At Crex Meadows, golden eagles are usually associated with the large areas of restored native prairie on the refuge portion of the wildlife area. Elsewhere in the Valley, wintering birds primarily use open agricultural fields.

Bald Eagle (*Haliaeetus leucocephalus*)

Status: Regular migrant, nesting species, and winter resident. This species is listed as threatened by the U.S. Fish and Wildlife Service. The WDNR has listed this species as endangered (Les 1979). Pesticides, nest-site destruction, and indiscriminate shooting are the main reasons for their decline.

Migration: Uncommon migrant throughout the Valley, fairly common at Crex Meadows, Burnett County. Spring migration begins in mid-February with a gradual movement from wintering areas along the lower St. Croix River. Peak spring migration occurs 10–25 March; most adults are on breeding territories by 1 April. Spring migration extends into early May; subadults arrive considerably later than adults.

Fall migration begins in late August, when juveniles move away from nesting areas. Peak fall migration occurs in two stages. Subadults reach peak numbers 1 October to 1 November and adults peak 15 October to 1 December. Most birds have departed by 15 December. Largest concentrations of migrants occur at Crex Meadows, Burnett County, and in areas directly adjacent to the St. Croix River.

Nesting Season Distribution: Rare nesting species throughout the Valley; nesting has been reported in Chisago, Burnett, Douglas, Pine, Pierce, and Polk counties. The Pierce County nesting pair was associated with the lower Kinnickinnic River. The pair abandoned their territory after a June 1973 storm destroyed the nest tree. Breeding populations in the St. Croix River Valley have been monitored continuously since the mid-1960's, and there is recent evidence that the population may be increasing.

inter: Fairly common winter resident primarily in the vicinity of open ater. Wintering birds at Crex Meadows regularly occupy open prairie reas. The distribution of wintering bald eagles closely follows the large ver systems of the Valley; birds are located primarily at Prescott (Pierce nd Washington counties) and St. Croix Falls (Polk and Chisago counties) long the St. Croix River, the Kettle River (Pine County), and Gordon lowage (Douglas County).

abitat: Nesting habitat of bald eagles consists of a complex of deciduous, oniferous, wetland, and shrub situations. In all instances, however, two rominent features (tall pine trees and nearby lakes or large rivers) occur. nfortunately for the eagles, these are two conditions that also attract man, nd several nesting territories in the Valley are endangered because of uman encroachment.

larsh Hawk (*Circus cyaneus*)

tatus: Regular migrant and nesting species, casual winter resident.

ligration: Fairly common migrant throughout the Valley, common at Crex leadows, Burnett County. Spring migrants arrive in the Western Upland bout 15 March; average arrival is about 20 March. Migrants arrive in the orthern Highland about 25 March. Peak migration occurs 1–20 April, and onbreeders depart by 1 May. Fall migration begins in mid-August and consts primarily of juveniles. Peak fall migration occurs 15 September to 5 October in the Central Plain and extends to 25 October at Crex Meadows. lost birds have departed by 15 November.

lesting Season Distribution: Uncommon nesting species throughout the alley, with nesting records for all counties. Apparently less numerous at resent than earlier as evidenced by Jackson (1941), who reported them as generally distributed . . . in favorable environments throughout the egion." Marsh hawks have been greatly reduced as a nesting bird in westrn Wisconsin since the mid-1960's.

inter: Casual midwinter resident in the Western Upland. Two midwinter ecords for Crex Meadows, Burnett County (9 February 1954, 25 February 953).

labitat: Marsh hawks use a wide range of grassland habitat types for esting. Nesting birds have been recorded in retired cropland (timthy–quackgrass), old field habitat, wetlands (primarily sedge meadows), nd restored prairie. In areas of intensive agriculture, nesting may regularly ccur in hayfields and occasionally in oat fields.

AMILY PANDIONIDAE: Ospreys

sprey (*Pandion haliaetus*)

tatus: Regular migrant and nesting species. The WDNR listed the species s endangered (Les 1979). Residual pesticides and loss of nesting habitat are considered reasons for their decline.

Migration: Uncommon migrant throughout the Valley, most regularly c served adjacent to the St. Croix River. Spring migrants arrive during t second week of April (earliest—22 March 1953, Burnett County a 26 March 1967, Washington County). Peak abundance of spring migran occurs between 25 April and 5 May. Fall migration begins with departu from nesting areas in mid-August. Peak fall migration occurs 25 August 15 September and departure by 10 October (latest—23 November 196 Chisago County).

Nesting Season Distribution: Ospreys are rare and local nesting speci north of St. Croix and Washington counties. The largest concentration breeding adults is near the Crex Meadows Wildlife Area in Burnett Count Sindelar (1971) observed at least four nests in Burnett and three in Po counties in the late 1960's.

Winter: M. R. Olson observed an osprey near Hudson, St. Croix County, c 31 December 1970.

Habitat: Nesting ospreys use a variety of habitat types including acid bog open lakes, and riverbanks. One of the most important habitat requirement is the presence of dead trees used for nest sites. Variations occur in the siz of the water body that attracts breeding pairs. Most breeding pairs I hav observed nest near a small lake (usually <20 ha), within 1.6 km of large lakes. Large bodies of water within proximity of a nesting site serve as im portant feeding areas for nesting ospreys.

FAMILY FALCONIDAE: Falcons

Gyrfalcon (*Falco rusticolus*)

Status: Accidental, one record.

Record: One was observed near Marine-on-St. Croix, Washington County on 24 December 1973 (Honetschlager 1974).

Peregrine Falcon (*Falco peregrinus*)

Status: Regular migrant and former nesting species. The U.S. Fish and Wildlife Service and WDNR (Les 1979) have listed this species as endangered. Pesticides, habitat loss, and human harassment are among the major causes of the decline.

Migration: Rare migrant throughout the Valley. Spring migrants arrive in the Western Upland 10–15 April (earliest—4 April 1974, Pierce County) and the Northern Highland 15–20 April. Departure from the Valley occurs 15–20 May. Fall migrants arrive 5–10 September and most observations occur during 15–30 September and departure by 15 October. During fall migration, the restored prairie on the refuge portion of Crex Meadows is the most consistent area in the Valley to observe this raptor.

Nesting Season Distribution: Formerly a rare and local nesting bird along he St. Croix River. Roberts (1932) reported that fewer than six pairs nested long the upper St. Croix River in the late 1920's. Surber (1919) reported a air of peregrine falcons along the St. Croix River near the mouth of the amarack River (Pine County) during July 1918. Jackson (1941) did not eport this species during the 1919 nesting season in northwestern Wis- onsin. Apparently the last known nesting attempt occurred along "the pper St. Croix River" in 1945 (Green and Janssen 1975).

Habitat: Roberts' (1932) description of peregrine falcons nesting "along the luffs" of the St. Croix River is all that is known of their nesting habitat in he Valley. Peregrine falcons presumably nested on the relatively inacces- ible rock ledges on the sides of the steepest bluffs. During migration, most eregrine falcons are observed in association with mudflats on large natural nd man-made wetlands. Open mudflats support migrant shorebirds and aterfowl and provide excellent hunting for falcons.

Merlin (*Falco columbarius*)

Status: Regular migrant and casual summer resident.

Migration: Rare migrant throughout the Valley. Spring migrants arrive in he Western Upland about 5-10 April and the Northern Highland 0-15 April. During spring migration the merlin is most frequently ob- erved 1-15 May and departs by 25 May (latest—28 May 1977, St. Croix ounty). Fall migrants arrive 25 August to 5 September and are most fre- uently observed 10-25 September. Departure from the Northern Highland ccurs 1-10 October and elsewhere by 20 October.

Nesting Season Distribution: Casual summer resident, restricted to the orthern Highland. Jackson (1941) mentioned the observation of an adult at ordon (Douglas County) on 28 July 1919. I observed an adult merlin near oose Junction (Douglas County, Sec. 14, T. 44 N., R. 15 W.) on 30 June 975 and 8 July 1977. Both observations were of lone birds. These dates pro- ide speculation of possible nesting, although neither nests nor young have een observed.

Habitat: My Douglas County observations were made in a large stand of owland Coniferous Forest. Predominant vegetation included trembling spen, green ash, black spruce, and balsam fir. These vegetative characteris- ics are usually associated with merlin breeding habitat in their normal reeding range in the boreal forest region of southern Canada. During igration, merlins regularly use a variety of both open and forested abitats.

American Kestrel (*Falco sparverius*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Abundant migrant in the Western Upland and Central Plain, ommon in the heavily forested regions of the Northern Highland. Spring migrants arrive in the Western Upland about 5–15 March and the Northern Highland 25 March to 5 April. Peak abundance through the Valley occurs 10–25 April. Fall migration begins in mid-August and peak abundance occurs 1–15 September. Most fall migrants have departed the Northern Highland by 15 October and elsewhere by 15 November.

Nesting Season Distribution: Common nesting species in the Western Upland and Central Plain, uncommon and more local in the Northern Highland.

Winter: Casual midwinter resident in the Central Plain and Western Upland.

Habitat: Primarily associated with scattered tree groves in agricultural areas, brushy edges of deciduous forest, and Old Field Community in southern areas. In the Northern Highland, American kestrels use edge situations associated with agricultural clearings, and areas that are managed for wildlife production. Wintering American kestrels are usually found along roadsides hunting from transmission wires and occasionally near feeding stations in residential areas.

FAMILY TETRAONIDAE: Grouse

Spruce Grouse (*Canachites canadensis*)

Status: Formerly a permanent resident, two recent records.

Distribution: Scott (1943*b*) reported that spruce grouse were last reported in 1928 or 1929 from the town of Dairyland (T. 43 N., R. 14 W.), Douglas County. Scott believed that at one time this species probably occurred throughout northern Wisconsin and south along the St. Croix River. The presumed range in Wisconsin extended south to central Polk County. Despite the presence of suitable spruce habitats in Pine County, this species is not known south of central St. Louis County in Minnesota (Green and Janssen 1975).

On 26 May 1978, R. Hoffman (personal communication) observed one spruce grouse in Sec. 33, T. 42 N., R. 15 W., Burnett County. Returning to the same area on 4 September 1978, Hoffman again observed a single spruce grouse.

Habitat: Scott (1943*b*) reported that spruce grouse are "almost always found only in spruce-balsam swamps" (= Lowland Coniferous Forest).

Ruffed Grouse (*Bonasa umbellus*)

Status: Regular permanent resident.

Distribution: Common resident in the Northern Highland and in the northern half of the Central Plain. Fairly common in the oak forests of the Central Plain and Western Upland. Breeding populations experience yearly fluctuaons that are almost predictable. Attempts to correlate these fluctuations ith changes in food availability have proved unsuccessful thus far.

abitat: Nesting ruffed grouse occur in a variety of upland deciduous forest ypes. In the Northern Highland and parts of the Central Plain, ruffed rouse are most commonly associated with medium-aged aspen forests that ontain scattered openings. In the Western Upland and areas of the Central lain adjacent to the St. Croix River, nesting ruffed grouse are associated ith medium-aged oak forests and woodlots. A well-developed shrub layer onsisting of prickly ash, thorn apple, and beaked hazel is usually associated ith high-quality ruffed grouse habitat.

reater Prairie Chicken (*Tympanuchus cupido*)

tatus: Extirpated as a natural breeding species; reintroduced in 1974.

ormer Distribution: Until the late 1890's, the greater prairie chicken was n abundant species on the prairies of Pierce and St. Croix counties and anged north to Grantsburg, Burnett County. Schorger (1943) summarized umerous accounts of the status of this species including newspaper acounts of abundance. Populations appeared to remain at high levels through 865. The winter of 1873 was reportedly very severe and St. Croix County armers reported the winter was extremely hard on the greater prairie hicken. Populations fluctuated considerably after 1875.

Reduced numbers of greater prairie chickens remained in St. Croix County ntil the 1920's, although they were still well distributed between Hammond nd New Richmond. The last greater prairie chicken observed in St. Croix ounty was shot near Hammond in 1932. At Crex Meadows, the last greater rairie chicken reported on a booming ground was observed in April 1949.

Former status of the greater prairie chicken in the Minnesota counties is oorly known. Roberts (1932) made no reference to this species in three counies considered in the present report. Greater prairie chickens were known to reed in the vicinity of the Twin Cities at the time of Roberts. A limited mount of information is provided by Partch (1970) in summarizing the emise of this species in central Minnesota. Partch shows that greater rairie chickens were common or abundant in southern Washington County 1849. Dispersal north through the Valley probably happened in the "late 800's." This movement northward along the St. Croix was attributed to gging and fires creating favorable openings in sandy areas. Surber (1919), describing an area of Pine County, stated that greater prairie chickens ear Hinckley occurred "in goodly numbers" in 1919. He made an appeal to cal residents to report illegal shooting so the "overflow" (of chickens) into urrounding areas would manifest another hunting season.

urrent Distribution: The WDNR began a greater prairie chicken reintrouction program at Crex Meadows during October 1974. This project met ith limited success during the first 2 years. In 1977, at least one female was bserved with a brood near the original release site. Continued research and abitat management at Crex Meadows may prove essential in the restoraion of this species in portions of its former breeding range.

Sharp-tailed Grouse (*Pedioecetes phasianellus*)

Status: Regular permanent resident.

Distribution: Sharp-tailed grouse were formerly well distributed throughou the Valley, with nest records from Pine, Polk, and St. Croix counties. Cu rently sharp-tailed grouse occur in northern Polk, central Burnett, easter and central Pine, and southwestern Douglas counties. The largest breedin populations occur at Crex Meadows, Burnett County, and on the shar tailed grouse management area near Solon Springs, Douglas County Dancing ground surveys from Crex Meadows indicate a fairly stable popu lation, with at least eight active dancing grounds in 1976 (WDNR files).

Away from the center of the sharp-tailed grouse breeding range, thi species is still occasionally observed in St. Croix County. A flock of 12 wa observed near Roberts on 13 October 1976, and a single bird observed nea Star Prairie on 1 November 1977.

Habitat: Sharp-tailed grouse are characteristic of mixed grasslands con taining small groves of oak or aspen trees or shrubs. At the grouse manage ment area in Douglas County, small patches of jack pine are commonl interspersed with grasslands. Most well-known sharp-tailed grouse breedin habitat in the Valley is characterized by restored prairie grasses on loos sandy soils.

FAMILY PHASIANIDAE: Quails and Pheasants

Bobwhite (*Colinus virginianus*)

Status: Regular permanent resident.

Distribution: The Valley is at the extreme northern limit of the bobwhit range. A very rare resident, restricted to Washington, St. Croix, and Pierc counties. Recent summer records from Crex Meadows in Burnett County ar probably released birds. Additionally, Green and Janssen (1975) report records of bobwhites in Pine County. Habitat loss coupled with winter stres have created a severe impact on bobwhite populations.

Habitat: Primary bobwhite habitat includes retired agricultural fields and Old Field Community intermixed with hedgerows and scattered shrubs. Much of this habitat continues to be altered or destroyed by expanding agricultural and urban development.

Ring-necked Pheasant (*Phasianus colchicus*)

Status: Introduced permanent resident.

Distribution: Fairly common resident of the Western Upland and Central Plain, rare to absent in the Northern Highland. Ring-necked pheasants were first introduced in western Wisconsin during the 1930's. Populations remained fairly stable through the 1950's and 1960's, primarily because of yearly releases by State wildlife agencies. Currently, ring-necked pheasant populations are reduced because of farming practices that eliminated most of their habitat. Urban expansion has not impacted this species to nearly the extent that agricultural production has. Green and Janssen (1975) stated that the largest populations remaining in Minnesota exist in the Twin Cities metropolitan area.

Habitat: The ring-necked pheasant is a species of agricultural areas, primarily edge habitats including field margins, fencerows, retired cropland, Old Field Communities, and heavily vegetated wetlands. Ring-necked pheasants in the Central Plain have shown an encouraging response to Managed Grasslands that are maintained for duck production.

Gray Partridge (*Perdix perdix*)

Status: Introduced permanent resident.

Distribution: Rare resident of the Western Upland. The small population that exists in the Valley is largely restricted to a small area of central St. Croix County. The largest population occurs near the village of Roberts in T. 29 N., R. 18 W.; T. 29 N., R. 17 W.; and T. 30 N., R. 17 W. Distribution of the population in the Minnesota counties is poorly known, although Mettler 1977) showed that the species range included southern Washington County. McCabe and Hawkins (1946) reported a population density of 0.6 coveys per 62 km in St. Croix County.

Habitat: The gray partridge is primarily a species of croplands and adjoinng edge habitat. Preferred habitats include corn and oats fields, weedy edges of summer fallow, and remnant patches of native prairie along railroad rights-of-way that border agricultural fields.

FAMILY GRUIDAE: Cranes

Sandhill Crane (*Grus canadensis*)

Status: Regular migrant and nesting species.

Migration: Rare migrant throughout the Valley, locally common at Crex Meadows, Burnett County. Sandhill cranes have been observed in Washngton County on four occasions: 31 March 1967, 9 April 1970 and 1971, and 20 November 1970. Three records exist for St. Croix County: 17 April 1947, 4 May 1974, and 30 October 1977. There is one record (29 April 1950) for Polk County.

The most reliable data on migration is from Crex Meadows, where the average date of spring arrival is 4 April (earliest—25 March 1976). Peak spring concentration occurs about 20 April. During fall migration, the first migrants arrive in early September and peak abundance is 15 October to November. During this period, concentrations of 150 to 200 individuals commonly occur on the refuge portion of Crex Meadows; high counts were 50 on 19 October 1975 and 420 on 30 October 1977. Departure of fall migrants occurs soon after freeze-up; the latest was on 18 November 1962.

Nesting Season Distribution: The first reported nesting in the Valley occurred in the Kohler–Peet area north of Crex Meadows along the St. Croi River in 1903. Roberts (1932) mentioned a local farmer reported sandhil cranes nesting in Burnett County from 1904 through 1930. Recent summe observations indicate that cranes still probably nest at Kohler–Peet; however, nests or young have not been observed.

Currently, sandhill cranes are fairly common during the nesting season a Crex Meadows. Recent surveys indicate that 30 to 40 pairs are nesting a that location. Elsewhere, Green and Janssen (1975) cited a 1950 nest recor near Beroun, Pine County. Johnson (1976) reported breeding season sandhil cranes in Thunder Meadow and the St. Croix River marshes, Pine County and in the extensive marshes of the Carlos Avery Wildlife Managemen Area, Chisago County, during 1974–75. Henderson (1978) showed tha breeding season sandhill cranes occurred in three Pine County townships: T 42 N., R. 16 W.; T. 41 N., R. 13 W.; and T. 38 N., R. 17 W.

Habitat: Breeding sandhill cranes are typically associated with large expanses of Northern Sedge Meadow characterized by tussock sedge, bristl sedge, fox sedge, bluejoint grass, rattlesnake grass, marsh cinquefoil, an marsh bellflower.

FAMILY RALLIDAE: Rails, Gallinules, and Coots

King Rail (*Rallus elegans*)

Status: Casual spring migrant and nesting species.

Migration: Rare spring migrant near the St. Croix River. Spring arrival dates range from 24 April 1977 in St. Croix County to 9 May 1958 in Burnett County. Fall migration records are not available.

Nesting Season Distribution: Observations at Crex Meadows, Burnett County, include 12 June 1969, 25 June 1975, 27 and 28 June 1956, 3 July 1963, and 12 August 1970. These breeding season records suggest possible nesting although nests or young have not been found. In St. Croix County, I observed a male king rail at East Twin Lake on 17 June 1976. Green and Janssen's (1975) Washington County record is the only confirmed nesting observation in the Valley.

Habitat: King rails at Crex Meadows are usually associated with dense cattail vegetation in man-made impoundments.

Virginia Rail (*Rallus limicola*)

Status: Regular migrant and nesting species, one winter record.

Migration: Common migrant in St. Croix, Polk, and Washington counties, uncommon to rare elsewhere. Spring migrants arrive about 25 April (earliest—16 April 1958, Burnett County): peak abundance is 10–15 May. Peak fall migration occurs between 20 September and 1 October and departure by 30 October.

Nesting Season Distribution: Fairly common nesting species in prairie wetands of St. Croix, Polk, and Washington counties. Uncommon to rare nesting species elsewhere in the Valley. One nest record was reported for Pine County in 1969 (Russell 1969).

Winter: One individual was observed on 30 December 1978 in Washington County (Suburban St. Paul CBC).

Habitat: Virginia rails use a variety of wetland classes for nesting. Greatest densities occur in seasonally and semipermanently flooded wetlands with cattail, river bulrush, and phragmites the predominant vegetation. Nesting Virginia rails are occasionally found in Northern Sedge Meadow habitats, along well-vegetated streams and in Shrub Carr wetlands.

Sora (*Porzana carolina*)

Status: Regular migrant and nesting species.

Migration: Common migrant in prairie wetlands of St. Croix, Polk, and Washington counties and at Crex Meadows in Burnett County. Fairly ommon to uncommon elsewhere. Spring migrants arrive about 25 April earliest—6 April 1964, Burnett County), reaching peak abundance 5-20 May. Peak abundance during fall migration occurs 10 September to 0 October and departure by 5 November.

Nesting Season Distribution: Common nesting species in prairie wetlands in he Western Upland and Central Plain, and at Crex Meadows. Uncommon lsewhere.

Habitat: Soras use a variety of wetland types for nesting. Highest densities ccur in seasonally and semipermanently flooded wetlands where cattail, ver bulrush, and softstem bulrush are the predominant vegetation types. oras also use wetlands that are more acidic, containing various species of aterlilies and pickerelweed. During high water periods, nesting soras also se sedge meadows.

ellow Rail (*Coturnicops noveboracensis*)

tatus: Casual migrant and summer resident.

igration: S. D. Robbins observed this species twice in central St. Croix ounty: 26 April 1961 and 17 May 1963. At Crex Meadows, Burnett ounty, apparent migrants were observed on 25 May 1976, 30 May 1977, nd 28 May 1978. R. Hoffman observed one at the Fish Lake Wildlife Area, urnett County, on 26 May 1979.

esting Season Distribution: The first record of the yellow rail in the Valley as obtained on 23 June 1962, when N. R. Stone observed a single bird at rex Meadows (Robbins 1963). During the summers of 1976 and 1977, ellow rails were again heard calling in a large Northern Sedge Meadow at rex Meadows. Although these birds were observed during normal nesting eriods, neither nests nor young were observed. Continued observations at

Crex Meadows may shed additional light on the breeding status of thi species.

Common Gallinule (*Gallinula chloropus*)

Status: Casual migrant and nesting species.

Spring Records: Gallinules were observed at Crex Meadows, Burnet County, on 9 May 1958 and 10 May 1976. In St. Croix County sprin records include 16 May 1961 and 25 May 1976. Washington County record range from 15–30 May.

Nesting Season Distribution: Green and Janssen (1975) showed a nestin record for Washington County. Since 1975, I have found common gallinul during the nesting season near Lake Elmo, Washington County. In Wisconsin, one bird was observed at Crex Meadows on 11 June 1958. The firs St. Croix County nesting record was obtained on 9 July 1976 near Sta Prairie. On 14 July 1977 an adult with a brood of three was observed on wetland near Hudson. Additionally, a single adult was observed nea Roberts on 11 August 1975.

Habitat: Most common gallinules observed during the nesting season ar associated with seasonally and semipermanently flooded wetlands. Thes wetlands typically support an abundant submerged and emergent flora.

American Coot (*Fulica americana*)

Status: Regular migrant and nesting species, casual in winter.

Migration: Abundant migrant throughout the Valley. Spring migrant arrive in the Western Upland about 10 March reaching the Northern Highland 1–10 April. Peak spring abundance occurs between 20 April and 1 May The first fall migrants arrive between 1 and 10 September. Peak fall abundance occurs 25 September to 10 October and departure by 15 November.

Nesting Season Distribution: Common nesting species on prairie wetlands i St. Croix, Polk, and Washington counties. Fairly common nesting species a Crex Meadows in Burnett County. Uncommon to rare elsewhere during th nesting season.

Winter: Casual early winter resident along the St. Croix River. Afton CB records include one each on 1 January 1957, 1971, 1972, 1974, and 1975. observed one along the Apple River, St. Croix County, on 19 Decembe 1977. During the winter of 1975–76, a single bird remained on the St. Croi River near Bayport, Washington County.

Habitat: American coots are characteristic of seasonally and semipermanently flooded wetlands. Predominant vegetation associated with America coot nesting habitat includes cattail, river bulrush, softstem and hardste bulrush, burreed, and phragmites. Nesting also occurs to a more limite extent on lower quality acidic wetlands characterized by waterlily an pickerelweed. Very few nesting pairs are found on riverine habitats.

AMILY RECURVIROSTRIDAE: Stilts and Avocets

merican Avocet (*Recurvirostra americana*)

tatus: Casual migrant.

ecords: There are three records from Crex Meadows, Burnett County: 0 April 1971, 16 May 1977, and 22 August 1965. One American avocet was bserved in St. Croix County near New Richmond on 13 May 1973.

AMILY CHARADRIIDAE: Plovers

emipalmated Plover (*Charadrius semipalmatus*)

tatus: Regular migrant.

igration: Fairly common migrant in the Western Upland and Central lain, rare to absent in the Northern Highland. The first spring migrants rive 25 April to 1 May (earliest—19 April 1976, St. Croix County). Peak bundance occurs 10-20 May and departure by 25 May. The first fall mi- rants arrive between 25 July and 1 August. Peak fall populations occur August to 1 September and departure by 25 September.

abitat: Most common on seasonally flooded wetlands. Uncommon on lake- ores and in short vegetation associated with semipermanently flooded etlands.

iping Plover (*Charadrius melodus*)

atus: Accidental, two records.

ecords: S. D. Robbins observed a single piping plover near Roberts, St. oix County, from 3 to 15 May 1967 (Robbins 1968). S. V. Goddard found e on the same wetland on 12 May 1972 (Faanes and Goddard 1976).

illdeer (*Charadrius vociferus*)

atus: Regular migrant and nesting species, casual in early winter.

igration: Abundant migrant in the Western Upland and Central Plain, mmon and more local in the Northern Highland. Spring migrants arrive out 15 March (earliest—2 March 1961, Burnett County); peak abundance 10-25 April. Fall migration begins about 10 August. Peak abundance curs 1-15 September and departure by 1 November.

sting Season Distribution: Common nesting species in the Western land and Central Plain, uncommon to rare and local in the Northern ghland.

nter: There are eight early winter records for an area in Washington unty; the dates are from 15 to 30 December. S. D. Robbins observed one in St. Croix County on 16 January 1964.

Habitat: Killdeer use a variety of habitats ranging from cropland, summe fallow, pastures, shorelines, and lawns to flat-topped roofs in residenti areas.

American Golden Plover (*Pluvialis dominica*)

Status: Regular migrant.

Migration: Fairly common spring and rare fall migrant in the Wester Upland, locally common during spring migration at Crex Meadows, Burnet County. Rare to absent elsewhere. Spring migrants arrive 20–25 April. Pea abundance occurs 10–15 May and departure by 1 June. Fall migrants arriv about 20 August and have departed by 15 October (latest—2 Novembe 1965, St. Croix County).

Habitat: Most commonly observed in temporarily flooded cornfields, alfalf or oat stubble, and are less common on mudflats and lakeshores. This plove uses habitat that is fairly dry and usually away from the edge of wetlan basins.

Black-bellied Plover (*Pluvialis squatarola*)

Status: Regular migrant.

Migration: Uncommon migrant in the Western Upland and Central Plai Locally common during spring at Crex Meadows, Burnett County, rare t absent in the Northern Highland. Spring migrants arrive about 5 May (ea liest—15 April 1975, St. Croix County). Peak abundance occurs 15–20 Ma and departure by 1 June. Fall migrants arrive 10–20 August. Peak abu dance occurs 5–20 September and departure by 15 October (latest—3 N vember 1976, St. Croix County).

Habitat: Unlike the preceding species, the black-bellied plover commonl uses temporarily flooded wetlands. Less common on flooded alfalfa or oa stubble and along the edge of semipermanently flooded wetlands.

FAMILY SCOLOPACIDAE: Sandpipers and Phalaropes

Hudsonian Godwit (*Limosa haemastica*)

Status: Regular migrant.

Migration: Rare spring migrant in the Western Upland and at Crex Mead ows, Burnett County. Most records are from central St. Croix and easter Washington counties. There are no fall records. The first migrants arriv 5–10 May. Flocks as large as 40 individuals have been observed 15–20 Ma and departure occurs by 30 May.

Habitat: Most individuals are observed on temporarily flooded agricultura ields. Occasional use is made of flooded alfalfa fields and edges of man-made mpoundments.

Marbled Godwit (*Limosa fedoa*)

Status: Regular migrant.

Migration: Rare and local migrant in the Western Upland and at Crex Meadows, Burnett County; most records are from central St. Croix County. Spring migrants arrive about 20 April. Peak numbers (five to seven) occur -10 May; departure is by 25 May. Fall migrants arrive about 25 July and depart by 1 September. W. Norling observed an injured marbled godwit at Grettum Flowage, Burnett County, on 8 November 1975.

Habitat: Observed primarily on temporarily flooded agricultural fields and long the edge of seasonally flooded wetlands.

Whimbrel (*Numenius phaeopus*)

tatus: Accidental, one record.

ecord: I observed one whimbrel along the north shore of East Twin Lake ear Roberts, St. Croix County, on 17 May 1976.

Long-billed Curlew (*Numenius americanus*)

tatus: Accidental, one record.

ecord: N. R. Stone observed one long-billed curlew at Crex Meadows, Burett County, on 25 May 1966 (Stone 1967).

pland Sandpiper (*Bartramia longicauda*)

tatus: Regular migrant and nesting species.

igration: Rare spring and fall migrant in the Western Upland and Central lain, casual to absent elsewhere. Spring migrants arrive 20–25 April. ecause most observations are of solitary or paired birds, dates of peak undance are difficult to establish. Fall migrants begin to arrive in late uly and have departed by 15 September.

esting Season Distribution: Rare and local nesting species in suitable grass abitat in the Western Upland and Central Plain, locally common at Crex eadows, Burnett County, and at the Sharp-tailed Grouse Management rea near Solon Springs, Douglas County. The latter site has been used nce at least 1919, when Jackson (1942) found "a dozen or more." Green and nssen (1975) considered the upland sandpiper "very scarce" in Pine ounty. One nest was found in Washington County in 1971. In northern erce and central St. Croix counties, this species was fairly common until 72. Increased conversion of remaining grasslands, primarily related to ending the Soil Bank Program, has caused their apparent extirpation in these two counties.

Habitat: Characteristic nesting species of tallgrass prairie such as at the Sharp-tailed Grouse Area, Douglas County, and in sedge meadows. Also regularly observed in unmowed alfalfa and timothy fields.

Greater Yellowlegs (*Tringa melanoleucus*)

Status: Regular migrant.

Migration: Fairly common migrant in the Western Upland and Central Plain, uncommon in the Northern Highland. Spring migrants arrive 30 March to 10 April. Peak abundance occurs 20 April to 5 May and departure by 25 May. The first fall migrants arrive about 10 July (earliest—3 July 1963, Burnett County). Peak abundance occurs 10–20 August, and departure by 30 October (latest—7 November 1975 and 10 November 1963, Burnett County).

Habitat: Greater yellowlegs occur in a variety of wetlands, flooded grasslands, plowed agricultural fields, Northern Sedge Meadow, and along the edge of seasonally, semipermanently, and permanently flooded wetlands. Primary use is made of flooded agricultural fields.

Lesser Yellowlegs (*Tringa flavipes*)

Status: Regular migrant.

Migration: Common to locally abundant migrant in the Western Upland and Central Plain, uncommon and local in the Northern Highland. Spring migrants arrive in the Western Upland 30 March to 5 April and the Northern Highland 10–15 April. Peak abundance occurs 1–10 May and departure by 30 May. The first fall migrants arrive about 10 July (earliest—4 July 1975, St. Croix County and 5 July 1960, Burnett County). Peak abundance occurs 1–10 August and departure by 15 October (latest—8 November 1975 and 10 November 1963, Burnett County).

Habitat: Lesser yellowlegs occur in a variety of wetland types, flooded alfalfa fields, and agricultural fields. Primary use is made of flooded agricultural fields.

Solitary Sandpiper (*Tringa solitaria*)

Status: Regular migrant.

Migration: Uncommon migrant in the Western Upland and Central Plain, rare and local in the Northern Highland. Spring migrants arrive 25–30 April. Peak abundance occurs from 5–15 May and departure by 25 May. Fall migrants arrive 5–15 July. Peak fall abundance occurs 25 July to 20 August and departure by 25 September (latest—10 October 1969, Washington County).

Habitat: Primarily found on flooded agricultural fields and the muddy edges of wetlands. This species is occasionally observed in Northern Sedge Meadow and Shrub Carr wetlands.

Willet (*Catoptrophorus semipalmatus*)

Status: Regular migrant.

Migration: Rare migrant in the Western Upland, casual elsewhere. Spring migrants arrive about 30 April. Willets are most frequently observed 5-10 May and remain through 25 May. The first fall migrants arrive about 25 July and have departed by 1 September.

Habitat: Willets are found primarily on temporarily and seasonally flooded wetlands. K. H. Dueholm observed a flock of 20 in a flooded alfalfa field in Polk County on 30 April 1975.

Spotted Sandpiper (*Actitis macularia*)

Status: Regular migrant and nesting species.

Migration: Common migrant in the Western Upland and Central Plain, uncommon and local in the Northern Highland. Spring migrants arrive in the Western Upland 20-30 April (earliest—2 April 1953, Burnett County) and peak abundance occurs 5-15 May. Peak fall abundance occurs during mid-August and departure by 1 October.

Nesting Season Distribution: Fairly common nesting species throughout the Valley. Nest records and observations of breeding pairs have been obtained from all the counties.

Habitat: Primarily a nesting species of seasonally, semipermanently, and permanently flooded wetlands in the Western Upland and Central Plain. This species also makes extensive use of river edge and exposed islands in arger streams. Largely restricted to rivers, streams, and rocky or sandy hores of large lakes in the Northern Highland.

Ruddy Turnstone (*Arenaria interpres*)

tatus: Regular migrant.

Migration: Rare and local migrant throughout the Valley. Spring migrants rrive about 10 May and are most commonly observed 15-25 May. Dearture occurs by 5 June (latest—10 June 1972, Burnett County). The obervation of 18 ruddy turnstones on Lake Chisago, Chisago County (Roberts 938), constitutes the largest group reported in the Valley. Fall migrants rrive about 20 August and have departed by 20 September.

abitat: Ruddy turnstones primarily use sandy beaches associated with rge lakes and the shoreline of the St. Croix River. Occasional use is made of easonally flooded wetlands.

Wilson's Phalarope (*Steganopus tricolor*)

Status: Regular migrant and summer resident, one nest record.

Migration: Fairly common migrant in the Western Upland, locally common in St. Croix County. Rare and local in the Central Plain and Northern Highland. Spring migrants arrive 20–25 April. Peak abundance occurs 10–15 May and departure by 1 June. The first fall migrants arrive 20–30 July. Peak abundance occurs 10–25 August and departure by 15 September.

Nesting Season Distribution: I observed an adult male with at least two young that still retained some down feathers on 10 July 1978 in St. Croix County. The wetland where this brood was observed (Sec. 11, T. 29 N. R. 18 W.) occasionally supports breeding plumaged adults during the nesting season in wet years. Numerous nesting season records from this wetland ranging from 9 June (1964) to 17 July (1961) suggest that nesting may have occurred earlier. Summer records from Crex Meadows, Burnett County (26 June 1974 and 27 June 1972), suggest that Wilson's phalarope may also nest at that location.

Habitat: Wilson's phalaropes use several wetland types during migration, including seasonally and semipermanently flooded wetlands. Summer records are from wetlands where cattail and river bulrush are the predominant vegetation types.

Northern Phalarope (*Lobipes lobatus*)

Status: Regular migrant.

Migration: Rare migrant in the Western Upland and at Crex Meadows, Burnett County. Casual elsewhere. Spring migrants arrive about 10 May (earliest—30 April 1974 and 1 May 1975, St. Croix County). Northern phalaropes are most commonly observed during the third week of May and depart by 5 June. Fall migrants arrive in mid-August (earliest—20 July 1975, St. Croix County) and depart by 15 September.

Habitat: Northern phalaropes are usually observed on semipermanently and permanently flooded wetlands that have poorly developed shoreline or emergent aquatic vegetation.

American Woodcock (*Scolopax minor*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants arrive about 25 March (earliest—14 March 1951, Polk County and 17 March 1955, Burnett County) and peak abundance occurs 20 April to 1 May. Fall migration begins in mid-August. Peak fall abundance occurs 15 September to 1 October and departure by 1 November.

Nesting Season Distribution: Fairly common and well distributed nesting species. Nesting has been recorded in all counties. Surber (1919) made reference to the abundance of this species in Pine County during the early 1900's.

Habitat: American woodcock use a variety of habitats for nesting. In the Western Upland, nesting birds use mesic Southern Deciduous Forest and Lowland Deciduous Forest. In the Central Plain and Northern Highland, open stands of medium-aged aspen and maple forest and Alder Thickets provide optimum nesting habitat. Recently, Deciduous Clear Cuts have been found to provide important nesting habitat.

Common Snipe (*Gallinago gallinago*)

Status: Regular migrant and nesting species, casual in winter.

Migration: Common to locally abundant migrant throughout the Valley. Spring migrants arrive in the Western Upland about 20 March, reaching the Northern Highland about 1 April. Peak abundance during spring migration occurs 20 April to 1 May. Fall migration begins with the flocking of family groups in mid-August. Peak abundance occurs between 25 September and 10 October and departure by 15 November.

Nesting Season Distribution: Uncommon nesting species in the Western Upland, common in the Central Plain and Northern Highland. Confirmed nest records have been obtained from Burnett and Polk counties.

Winter: There are eight late December records ranging from 19 December 1976) to 3 January (1976) in St. Croix and Washington counties. These are all CBC records. The largest count was 12 individuals on the Suburban St. Paul CBC, 30 December 1961. There is only one midwinter record (15 Feb-uary 1973, Pierce County) for the Valley.

Habitat: Highest densities of nesting common snipe occur in Northern Sedge Meadow. Stream banks and semipermanently flooded wetlands provide important habitat in the Central Plain and Western Upland. In the Northern Highland, breeding common snipe use openings in Black Spruce–Tamarack Bogs and Alder Thicket, in addition to Northern Sedge Meadow.

Short-billed Dowitcher (*Limnodromus griseus*)

Status: Regular migrant.

Migration: Uncommon to rare migrant throughout the Valley. Most records re from the Western Upland and from Crex Meadows, Burnett County. Spring migrants arrive about 10 May and have departed by 30 May. Fall migrants arrive about 25 July (earliest—9 July 1965, St. Croix County) and ave departed by 15 September. A short-billed dowitcher that I banded near Roberts, St. Croix County, on 16 August 1975 was recovered in Guyana, outh America, in September 1976. Identification of this species and the ong-billed dowitcher is compounded by nearly identical plumage characeristics.

Habitat: Largely restricted to flooded alfalfa and stubble fields and borders of seasonally and semipermanently flooded wetlands.

Long-billed Dowitcher (*Limnodromus scolopaceus*)

Status: Regular migrant.

Migration: Uncommon migrant in the Western Upland and Central Plain rare to absent in the Northern Highland. Spring migrants arrive in the Western Upland 20–25 April and the Northern Highland about 1 May. This species is most frequently observed about 10 May and departs by 15 May Fall migrants arrive about 10 August (earliest—17 July 1976, St. Croix County). Peak abundance occurs 25 August to 5 September and departure by 5 October (latest—25 and 28 October 1960, St. Croix County; Robbins 1961).

Correct identification of both dowitcher species is difficult because of their similar appearance. To assure positive identification, recognition of their call notes is important. The long-billed dowitcher has a short, two-note "twee twee" call. The short-billed dowitcher call consists of three notes in close succession. This call, "tu-tu-tu," is similar to the greater yellowlegs.

Habitat: Primarily a species of flooded agricultural fields, temporarily, seasonally, and semipermanently flooded wetlands.

Red Knot (*Calidris canutus*)

Status: Casual migrant.

Records: Single red knots were observed in St. Croix County on 12 May 1966 and 13 May 1975. Three birds were observed at Crex Meadows, Burnett County, on 19 May 1972, and single birds on 13 June 1968 and 17 August 1960 (Kemper 1961).

Sanderling (*Calidris alba*)

Status: Regular migrant.

Migration: Rare spring and very rare fall migrant in the Western Upland and at Crex Meadows, Burnett County; absent in the northern forested regions. Spring migrants arrive about 10 May (earliest—30 April 1973, St. Croix County and 2 May 1969, Washington County) and have departed by 30 May. Fall migration is between 15 August and 10 September.

Habitat: Sanderlings are primarily found on sandy or rocky beaches associated with large lakes and sandbars on the St. Croix River. Occasional use is made of drier portions of exposed mud associated with seasonally flooded wetlands and man-made impoundments.

Semipalmated Sandpiper (*Calidris pusillus*)

Status: Regular migrant.

igration: Common to locally abundant migrant in the Western Upland and entral Plain, rare and local in the Northern Highland. Spring migrants rrive about 5 May, reaching peak abundance 15–30 May. Departure occurs -10 June (latest—13 June 1965 and 17 June 1977, St. Croix County). Fall igrants arrive about 20 July. Peak abundance occurs 10–20 August and eparture by 5 October (latest—16 October 1964; Kemper 1965).

abitat: Primarily a species of flooded agricultural fields, exposed edges of etlands, man-made impoundments, and sandbars associated with islands the St. Croix River.

estern Sandpiper (*Calidris mauri*)

tatus: Casual migrant.

ecords: There are spring records from St. Croix County including 2–4 May 975 (peak of 11 on 3 May), 13 May 1976, 25 May 1963, 31 May 1965, and June 1966. There are five fall records including three in St. Croix County; August 1977, 14 August 1975, and 19 August 1974. At Crex Meadows, urnett County, one western sandpiper was observed on 15 and 21 August 955, and on 12 October 1974.

abitat: The St. Croix County observations included birds associated with e exposed edge of a semipermanently flooded wetland. The Burnett ounty record was obtained from the exposed edge of a man-made impound- ent.

east Sandpiper (*Calidris minutilla*)

atus: Regular migrant.

igration: Common spring and fairly common fall migrant in the Western pland and Central Plain, rare and local in the Northern Highland. Spring grants arrive about 30 April (earliest—23 April 1959, Burnett County). ak abundance occurs 5–15 May and departure by 25 May. Fall migrants ive 5–10 July (earliest—25 June 1972, Chisago County). Peak abundance urs 25 July to 10 August and departure by 30 September.

bitat: Primarily a species of flooded agricultural fields, exposed edges of tlands, and sandbars associated with St. Croix River islands.

hite-rumped Sandpiper (*Calidris fuscicollis*)

tus: Regular migrant.

gration: Fairly common spring migrant in the Western Upland, uncom- n to rare elsewhere. Uncommon to rare throughout the Valley in fall. ing migrants arrive about 10 May (earliest—20 April 1974, St. Croix nty). Peak abundance occurs 20 May to 5 June and departure by 1 June. Fall migrants arrive about 20 July and depart by 15 September est—6 October 1964, Kemper 1965). Peak fall populations cannot be ermined because of few records.

Habitat: Primarily a species of flooded agricultural fields and muddy edges of seasonally flooded wetlands.

Baird's Sandpiper (*Calidris bairdii*)

Status: Regular migrant.

Migration: Rare spring and uncommon fall migrant in the Western Upland, rare to absent elsewhere. Spring migrants arrive about 5 May (earliest—20 April 1974, St. Croix County) and depart by 5 June. Fall migrants return 15–20 August and depart by 15 September.

Habitat: Primarily a species of temporarily flooded agricultural fields and edges of seasonally flooded wetlands.

Pectoral Sandpiper (*Calidris melanotos*)

Status: Regular migrant.

Migration: Common to locally abundant spring and common fall migrant in the Western Upland and Central Plain, uncommon in the Northern Highland. Spring migrants arrive about 15 April (earliest—4 April 1964 and 1976, St. Croix County) and peak abundance occurs 5–10 May. During this period, flocks of up to 150 individuals are commonly observed. Spring migrants depart by 1 June. Fall migrants return about 10 July, and peak abundance is 15 August to 1 September. Small flocks are observed in early October and departure occurs by 30 October (latest—15 November 1964, Burnett County; Kemper 1965).

Habitat: Pectoral sandpipers use a variety of wetland habitats including temporarily flooded, Northern Sedge Meadow, Shrub Carr, exposed muddy edges of seasonally flooded wetlands and man-made impoundments, and St. Croix River islands.

Dunlin (*Calidris alpina*)

Status: Regular migrant.

Migration: Uncommon migrant throughout the Valley. Spring migrants arrive about 5 May, reaching peak abundance 15–20 May. Departure occurs 1–5 June. Fall migrants arrive about 20 August and have departed by 10 October (latest—28 October 1960, St. Croix County).

Habitat: Primarily a species of temporarily and seasonally flooded wetlands, man-made impoundments, and St. Croix River islands.

Stilt Sandpiper (*Micropalama himantopus*)

Status: Regular migrant.

Migration: Rare spring and uncommon fall migrant in the Western Upland, rare to absent elsewhere. Spring migrants arrive about 5 May (earliest—

19 April 1975, St. Croix County). Peak abundance occurs 15–20 May and departure by 25 May. Fall migrants arrive 25 July to 1 August and depart by 25 September.

Habitat: Primarily a species of seasonally flooded wetlands, muddy edges of man-made impoundments, and St. Croix River islands.

Buff-breasted Sandpiper (*Tryngites subruficollis*)

Status: Casual migrant.

Records: There are five records from central St. Croix County: 10 May 1974, 31 July 1967, 11 August 1975, 1 September 1968, and 9 September 1975.

Habitat: All St. Croix County records were obtained from the edge of a semipermanently flooded wetland in Sec. 11, T. 29 N., R. 18 W.

FAMILY STERCORARIIDAE: Jaegers

Parasitic Jaeger (*Stercorarius parasiticus*)

Status: Accidental, two records.

Record: One adult was observed and photographed on 28 and 29 August 1957, on Phantom Lake at the Crex Meadows Wildlife Area, Burnett County (Lound and Lound 1958*a*). D. D. Tessen observed an adult at Crex Meadows on 28 May 1978 (Tessen 1979*a*).

FAMILY LARIDAE: Gulls and Terns

Herring Gull (*Larus argentatus*)

Status: Regular migrant and casual summer resident.

Migration: Common migrant throughout the inland areas, locally abundant along the St. Croix River. Spring migrants return in late February and reach peak abundance 25 March to 20 April. Most have departed by 15 May (latest—25 May 1969, Washington County). Fall migrants arrive during the last 2 weeks of September. Peak abundance occurs 15 October to 1 November and birds depart by 15 December.

Summer: A casual summer resident along the lower St. Croix River. Herring gulls summered in Washington County in 1968 and were observed in Washngton County from 14 to 19 July 1975 (Eckert 1976).

Winter: A casual early winter resident in the lower St. Croix River Valley. On 1 January 1972 and 1 January 1975, two herring gulls were observed along the St. Croix River near Hudson (Afton CBC).

Habitat: Largely restricted to larger water bodies, including permanent akes and the St. Croix River.

Ring-billed Gull (*Larus delawarensis*)

Status: Regular migrant.

Migration: Abundant spring and fall migrant throughout the Valley. Spring migrants return 10–20 March. Peak abundance occurs between 15 April and 1 May and departure by 20 May. Fall migrants arrive in early September (earliest—24 August 1961, Burnett County). Peak abundance occurs between 15 September and 1 October. Flocks totaling 200 individuals are common during this period, and flocks of 500 are regularly observed. Fall migrants depart by 10 November (latest—17 November 1965, St. Croix County and 26 November 1976, Washington County).

Habitat: Ring-billed gulls use a variety of wetland types during migration including semipermanently and permanently flooded wetlands, large lakes, and the St. Croix River. During fall migration, ring-billed gulls make extensive use of recently plowed agricultural fields.

Franklin's Gull (*Larus pipixcan*)

Status: Regular migrant.

Migration: Rare migrant in the Western Upland and at Crex Meadows, Burnett County; absent from the forested regions. Spring migrants arrive between 25 April and 1 May (earliest—13 April 1954, Burnett County) and departure occurs by 25 May. Fall migrants arrive 20–25 September. Peak abundance occurs 1–20 October and departure by 10 November. During peak fall migration, Franklin's gulls are commonly found in association with ring-billed gulls on freshly plowed agricultural fields in western St. Croix County. Flocks of 200 to 300 are not uncommon and during the mid-1960's, S. D. Robbins occasionally found flocks of 1,500 Franklin's gulls in mid-October. Migrants follow a rather narrow migration path through the Western Upland; the major route is associated with the area of Prairie Wetlands. Franklin's gull is virtually absent east of R. 17 W. in St. Croix and Polk counties.

Habitat: Largely restricted to semipermanently and permanently flooded wetlands. Extensive use is made of agricultural fields during fall migration.

Bonaparte's Gull (*Larus philadelphia*)

Status: Regular migrant.

Migration: Uncommon migrant throughout the Valley, fairly common on the prairie wetlands of St. Croix and Washington counties. Spring migrants return between 25 April and 1 May (earliest—12 April 1971, Washington County). Peak abundance occurs 10–15 May and departure by 25 May. Fall migrants arrive about 10 September. Peak abundance occurs 20 September to 1 October and birds depart by 25 October. During the fall, Bonaparte's gulls are most commonly found along the St. Croix River, becoming rare to absent elsewhere.

Habitat: Primarily a species of large semipermanently and permanently flooded wetlands, and open expanses of the St. Croix River.

Ivory Gull (*Pagophila eburnea*)

Status: Hypothetical.

Record: N. R. Stone observed three adults at the Crex Meadows Wildlife Area, Burnett County, on 3 April 1959 (Stone 1959*b*).

Sabine's Gull (*Xema sabini*)

Status: Hypothetical.

Record: A single immature was observed on 1 October 1944 along the St. Croix River at Stillwater, Washington County (Longley 1947).

Common Tern (*Sterna hirundo*)

Status: Regular migrant and casual summer resident.

Migration: Fairly common migrant near the St. Croix River, uncommon to are elsewhere in the Western Upland and Central Plain, and rare to absent n the Northern Highland. Spring migrants arrive 20–25 April. Peak spring bundance occurs 10–20 May and departure by 30 May. Fall migrants eturn 25 August to 5 September and depart by 25 September.

Nesting Season Distribution: A casual summer resident in St. Croix and Washington counties; most summering birds are found along the St. Croix River. Establishment of nesting common terns along the lower St. Croix is eemingly possible, because a small group of common terns summer near the onfluence of the Minnesota and Mississippi rivers at Ft. Snelling in the win Cities. Excessive recreational use of exposed beaches and sandy lands in the lower St. Croix is probably a major factor limiting colony stablishment. If colonies are established at a future date, intensive restricon of human use will be necessary.

abitat: Primarily a species of large permanently flooded wetlands and ndy beaches and islands of the St. Croix River.

east Tern (*Sterna albifrons*)

atus: Accidental, one record.

cord: R. A. Knuth observed an adult on Phantom Lake, Crex Meadows ildlife Area, Burnett County, on 17 August 1971 (Roberts and Roberts 72). This bird was observed by over 60 people during a Wisconsin Society Ornithology field trip.

Forster's Tern (*Sterna forsteri*)

Status: Regular migrant and casual summer resident. The WDNR listed thi species as endangered (Les 1979).

Migration: Fairly common spring and rare fall migrant in the Wester Upland and Central Plain, casual in the Northern Highland. Spring migrants arrive 20–25 April and are most commonly observed 5–15 May. Departure of spring migrants occurs by 25 May. Fall migrants arrive betwee 1–5 September and depart by 1 October.

Summer: A casual summer resident in St. Croix and Washington counties The presence of summering birds suggests nesting; however, no nests o young have been recorded. This tern occurs with greatest frequency durin the summer on the wetlands in St. Croix and Washington counties.

Habitat: Migrants are observed in association with large semipermanentl and permanently flooded wetlands. Observations of summering birds hav been restricted primarily to permanently flooded wetlands that suppor extensive growths of cattail and hardstem bulrush along the periphery o the basin.

Caspian Tern (*Sterna caspia*)

Status: Regular migrant.

Migration: Rare migrant in the Western Upland, casual or absent elsewhere Spring migrants arrive about 1 May (earliest—8 April 1961, Burnett County). Peak abundance occurs 10–20 May and departure by 25 May (latest—30 May 1924, Chisago County; Roberts 1938: 2 June 1974, Washington County; Eckert 1975). Fall migrants arrive about 1 September an have departed by 25 September. During both migration periods, Caspia terns are most regularly observed on the St. Croix River. Away from th river, they are less common and more irregular in occurrence.

Habitat: Largely restricted to open expanses of the St. Croix River and larg permanently flooded wetlands.

Black Tern (*Chlidonias niger*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant in the Western Upland and Central Plain; uncommon in the Northern Highland. Spring migrants arrive 25 April to 1 May, reaching peak abundance about 15 May. Fall migrants reach peak numbers about 10 August and have departed by 1 September (latest—4 October 1965, Washington County).

Nesting Season Distribution: A fairly common nesting species in the prairie wetland region of St. Croix, Washington, and southern Polk counties, becoming less common in the forested regions. Breeding populations of the black tern have declined sharply in Wisconsin. During 1966–75, Robbins (1977) noted a 14% annual decrease in the statewide breeding population. A census of breeding black terns in St. Croix County showed a decrease from 42 pairs in 1975 to 9 pairs in 1977 (Faanes 1979).

Habitat: Black terns are a characteristic species of large seasonally and semipermanently flooded wetlands that support an abundance of emergent aquatic vegetation. Most nests that I have examined were on a floating vegetation mat, usually composed of submerged plants and emergent plant leaves. In the northern forested regions, black terns are less common as a nesting species. In this region, large, acidic wetlands are most regularly used for nesting.

FAMILY COLUMBIDAE: Pigeons and Doves

Rock Dove (*Columba livia*)

Status: Regular permanent resident.

Distribution: An abundant permanent resident in cities, towns, and near farm buildings. Uncommon to rare away from human habitation.

Mourning Dove (*Zenaida macroura*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Abundant migrant in the Western Upland and Central Plain, ncommon and more local in the Northern Highland. Spring migrants arrive n mid-March, reaching peak abundance 5–15 April. Fall migration begins with flock formation among immatures in mid-August. Peak abundance ccurs between 15 September and 1 October, and most birds depart by 5 October. Several nestlings that I banded in this region were recovered in southern Texas by the end of September during the same year of banding.

Nesting Season Distribution: The mourning dove is an abundant nesting pecies in the Western Upland and Central Plain. In the Northern Highland, mourning doves are uncommon to rare nesting birds. Mourning doves have rather long nesting season at this latitude; nest dates range from 18 April o 20 September.

Winter: A fairly common winter resident in the Western Upland, rare to bsent elsewhere. The CBC data indicate that the early winter distribution centered in St. Croix and Washington counties.

abitat: A characteristic edge species, occurring in largest densities in Pine lantations, shelterbelts, and fencerows. Occurs fairly commonly in ornaental coniferous trees planted in residential areas.

assenger Pigeon (*Ectopistes migratorius*)

atus: Extinct.

ecords: The destruction of this species across North America has been well cumented. Passenger pigeons were a common nesting species in the

Valley until the 1880's. Schorger (1955) described their distribution and cited the last record at New Richmond, St. Croix County, on 28 September 1887. Roberts (1932) mentioned a "pigeon nesting" that was located between White Bear Lake and Taylors Falls in the late 1800's. This location may have been in either Chisago or Washington county.

FAMILY CUCULIDAE: Cuckoos and Anis

Yellow-billed Cuckoo (*Coccyzus americanus*)

Status: Regular migrant and nesting species.

Migration: Uncommon migrant in the Western Upland, rare elsewhere. Spring migrants begin to arrive between 15 and 20 May, and become well distributed over the breeding range by 5 June. There is a general exodus of fall migrants 15 August to 10 September, and the last birds depart by 20 September.

Nesting Season Distribution: An uncommon nesting species in Pierce, St. Croix, and Washington counties. Occasional summer records exist for northern Polk and southern Burnett counties. Roberts (1932) mentioned summer records for Pine County and observed that in northern areas this species "seems to vary considerably in numbers, both as to locality and season."

Habitat: A characteristic species of brushy margins, woodlot openings, brushy fencerows, and field edges. Most breeding season adults that I observed were associated with medium-aged stands of Southern Deciduous Forest; red oak and Hill's oak were the predominant vegetation type.

Black-billed Cuckoo (*Coccyzus erythropthalmus*)

Status: Regular migrant and nesting species.

Migration: Uncommon spring and fall migrant throughout the Valley. Spring migrants arrive in the Western Upland between 5 and 10 May, becoming most numerous during the last 2 weeks of May. Night migrants are frequently heard during the first week of June (S. D. Robbins, personal communication). Arrival in the Northern Highland occurs 15–20 May. Peak fall abundance occurs between 1 and 10 September and departure by 25 September.

Nesting Season Distribution: A fairly common nesting species throughout the Valley, although more common in the Central Plain and Northern Highland. Roberts (1938) reported that "a dozen" black-billed cuckoo nests were found during June 1926 in Chisago County.

Habitat: Brushy margins of mature Northern Deciduous Forest, Deciduous Clear Cuts, and mixed coniferous–deciduous forest.

Groove-billed Ani (*Crotophaga sulcirostris*)

Status: Accidental, one record.

Record: One adult was shot in Woodbury Township, Washington County, on 20 October 1968 (Litkey 1969). The specimen was deposited in the museum ollection at the University of Wisconsin-River Falls.

AMILY STRIGIDAE: Typical Owls

creech Owl (*Otus asio*)

tatus: Regular permanent resident.

istribution: Uncommon permanent resident in the Western Upland and entral Plain, rare to absent elsewhere. Bernard (1967) did not report this pecies in Douglas County. Green and Janssen (1975) reported that screech wls are resident in Carlton County, indicating possible residence in Pine ounty. Documented nesting records exist for Pierce, St. Croix, and Wash- gton counties.

abitat: Breeding screech owls are restricted primarily to mature deciduous rests. Most breeding pairs that I have encountered were associated with owland Deciduous Forest that was dominated by cottonwood, American m, and green ash. In agricultural areas, breeding screech owls are asso- ated with oak woodlots and they are regularly observed using ornamental ee plantings in residential areas.

reat Horned Owl (*Bubo virginianus*)

atus: Regular permanent resident.

stribution: Common permanent resident throughout the Central Plain and rthern Highland, fairly common (locally common) in the Western Upland. ckson (1942) reported great horned owls were generally distributed in rthwestern Wisconsin.

abitat: Nesting great horned owls use a variety of habitats, including wland Deciduous Forest, mature Northern Hardwood Forest, oak wood- s, Pine Plantations, Lowland Coniferous Forest, and Southern Deciduous rest.

ng-eared Owl (*Asio otus*)

atus: Regular migrant and nesting species, casual winter resident.

gration: Rare spring and fall migrant throughout the region. Spring mi- ants arrive 1-15 March and are most commonly seen 20 March to April. Fall migrants arrive about 1 October and most have departed by ecember.

sting Season Distribution: Rare nesting species throughout the Valley. sting has been reported in Washington County (Christenson and Fuller 5). In St. Croix County, the first nest record was obtained near Hudson 973, and this pair also produced young in 1974. In Polk County, nesting long-eared owls were found in the McKenzie Creek Wildlife Area (T. 37 N R. 16 W.) and the Sterling Pine Barrens (T. 36 N., R. 20 W.) during 1972–74 In Burnett County, nests have been found in jack pine habitat west o Grantsburg. Although breeding records are lacking for other counties in th Valley, nesting is expected in suitable habitat.

Winter: Rare winter resident in the Western Upland, casual north of thi area.

Habitat: Nesting long-eared owls are usually associated with pine forest and Pine Plantations. The St. Croix County pair was found in a small valley of Southern Deciduous Forest. Wintering long-eared owls are usually associated with Pine Plantations and young pine forests.

Short-eared Owl (*Asio flammeus*)

Status: Regular migrant, casual summer and rare winter resident, one nes record.

Migration: Rare migrant throughout the Valley. Spring migrants arrive about 15 March and are most commonly observed 15–30 April. Mos have departed by 10 May. Fall migrants arrive about 25 September. Peak numbers occur 30 October to 1 December and most depart by 15 December.

Nesting Season Distribution: C. R. Elliott observed a short-eared owl nes with three young in St. Croix County on 15 June 1978. This nest was located in a Managed Grassland on the Oakridge Waterfowl Production Area near New Richmond (Sec. 17, T. 31 N., R 17 W.). This represents the only known nest record for the Valley. The presence of additional midsummer records from Crex Meadows, Burnett County (1968–74), Polk County (1974), and St Croix County (1976) suggest that this species nests sparingly throughout the Valley in suitable habitat. There are no known summer records for the Minnesota counties.

Winter: Rare winter resident in St. Croix, Washington, and Burnett counties. Although most records are from the CBC, two mid-January records exist for Crex Meadows.

Habitat: All breeding season records of this species have been made from Northern Sedge Meadow and retired grassland habitats. Wintering short-eared owls occur in sedge meadows and grassy fields.

Snowy Owl (*Nyctea scandiaca*)

Status: Regular migrant and winter resident.

Migration: Rare spring and fall migrant throughout the Valley. Yearly abundance varies considerably and migrating and wintering populations appear to be regulated by a 4-year cycle of small mammal populations on this species' tundra breeding areas. Fall migrants arrive in mid-November (earliest—14 October 1918, Pine County; 2 November 1963, Crex Meadows) and during "invasion" years, reach peak abundance 15 December to 1 January

Spring migration begins in late February and departure occurs by 1 April (latest—9 April 1967, Crex Meadows and 18 April 1974, St. Croix County).

Winter: Rare and local winter resident throughout the Valley. During years of peak abundance, snowy owls are fairly common winter residents at Crex Meadows, Burnett County; occasional concentrations range from six to eight birds.

Habitat: Wintering snowy owls regularly use open agricultural fields and Northern Sedge Meadow or Shrub Carr. Occasionally found associated with semipermanently flooded wetlands in the Western Upland and Central Plain. At Crex Meadows, extensive use is made of restored tall grass prairie and Northern Sedge Meadow.

Barred Owl (*Strix varia*)

Status: Regular permanent resident.

Distribution: Fairly common (locally common) in the Central Plain and Northern Highland, common in the Western Upland. There is apparently little difference in status between nesting and winter seasons.

Habitat: Characteristic species of mature Northern Hardwood Forest in the Central Plain and Northern Highland. Predominant vegetation of barred owl habitat includes basswood, sugar maple, trembling aspen, green ash, and white pine. Lowland Coniferous Forest that contains mature yellow birch and black spruce provides important breeding habitat in the Northern Highland. In the Western Upland, the barred owl is characteristic of mature Lowland Deciduous Forest and reaches greatest densities in large expanses of this vegetation type associated with major streams that are tributary to the St. Croix River.

Great Gray Owl (*Strix nebulosa*)

Status: Casual winter resident, one nest record.

Records: One was found dead near Lake Elmo, Washington County, on 15 February 1969 (Green 1969). Another individual was observed at the Northwoods Audubon Center, Pine County, on 27 January 1973. D. G. Follen (personal communication) reported a single great gray owl several times in "early November" 1979, 16 km east of Moose Junction, Douglas County (T. 44 N., R. 13 W.). Follen also reported a great gray owl during November 1979 in extreme northwestern Washburn County, Wisconsin, near the Douglas and Burnett County border.

Nesting Season Distribution: Follen (1979) provided the only evidence of great gray owl nesting in the Valley. On 18 August 1978, he observed two immature great gray owls 0.6 km north of Moose Junction, Douglas County Sec. 7, T. 44 N., R. 14 W.). The estimated age of these birds was 6–8 weeks. During the observation, an adult was seen and heard nearby. On 19 August 1978, three immatures and one adult were observed at the same location and a stick nest found.

Habitat: Vegetation adjacent to the Douglas County nest was Lowland Coniferous Forest dominated by black spruce, white birch, and green ash Vast areas of similar habitat exist in southwestern Douglas and adjacent Pine counties. Continued observations in this region may reveal additiona breeding records.

Hawk Owl (*Surnia ulula*)

Status: Casual winter resident.

Records: Bernard and Klugow (1963) provided the most evidence of hawk owl occurrence in the Valley. They reported three observations of hawk owls in Douglas County including "one bird 5.6 km north of Dairyland (T. 44 N. R. 14 W.), in early March 1963." On 17 March 1963, a dead hawk owl was found 16 km west of Solon Springs (T. 45 N., R. 13 W.) and on 20 March 1963 another hawk owl (possibly the first individual) was observed 8.8 km northeast of Dairyland. Other records include one bird collected at Stacy, Chisago County, on 20 October 1962, and two birds observed in Pine County on 17 February 1963 (Green 1963).

These observations were made during a winter that produced an "invasion" of hawk owls in northwestern Wisconsin and much of northern Minnesota. Later that same year, the nests and young of two separate pairs were found in northeastern Douglas County. The hawk owl is included as casual rather than accidental, because the species is well known for occasional irruptions into southern areas during the winter (cf. Green 1963; Eckert 1978). Because large expanses of excellent hawk owl habitat (Lowland Coniferous Forest) occur in southern Douglas and adjacent Pine counties, I would expect additional records of this owl during future "invasions."

Boreal Owl (*Aegolius funereus*)

Status: Casual winter resident.

Records: There are two records for Burnett County: 19 December 1952 at Crex Meadows (N. R. Stone), and 13 April 1975 near the Fish Lake Wildlife Area (W. Norling). In Pine County, one was observed on 9 November 1972.

Saw-whet Owl (*Aegolius acadicus*)

Status: Regular migrant and winter resident.

Migration: Rare migrant throughout the Valley. Spring migrants arrive in mid-March, and most observations occur between 25 March and 15 April (latest—16 May 1961, St. Croix County). Fall migrants arrive in mid-September and most have departed by 15 December. This species is one of the least common regular owls in the Valley. At Hawk Ridge near Duluth, Minnesota, saw-whet owls are the most common migrant owl (Evans 1975). No doubt their small size, nocturnal habits, and very secretive behavior contribute to the scarcity of records.

On 24 May 1978, C. A. Kemper and S. D. Robbins heard saw-whet owls calling in four separate locations about 15 km west of Solon Springs, Douglas County. S. D. Robbins (personal communication) suggests that the saw-whet owl probably nests in the upper Valley.

Winter: Apparently a casual winter resident until mid-January. Several late December records exist from the Afton, St. Paul Suburban (Washington County) and New Richmond (St. Croix County) CBC. Also, there are several January records from Burnett County. The recent increased interest in "owling" with tape-recorded calls may help to better establish the winter tatus of this species.

Habitat: Most records of wintering saw-whet owls have been from medium-ged Pine Plantations and mature pine forests.

FAMILY CAMPRIMULGIDAE: Goatsuckers

Whip-poor-will (*Camprimulgus vociferus*)

tatus: Regular migrant and nesting species.

Migration: Fairly common migrant throughout the Western Upland and entral Plain, locally common in the Northern Highland. Most records are of irds on breeding territory, rather than actual migrants. Spring migrants rrive 1–5 May and are widely distributed by 10–20 May. Jackson (1942) re-orted that whip-poor-wills were common at Danbury, Douglas County, uring late May 1918. The status of this species in the fall is poorly under-ood. Whip-poor-wills are quiet during this period and they are almost ever reported. Most observations have been made between 20 August and 0 September (latest—22 October 1964, Burnett County).

esting Season Distribution: Fairly common and local nesting species roughout the Central Plain and Northern Highland, uncommon and local the Western Upland.

abitat: In the Western Upland, nesting whip-poor-wills are found asso-ated with mixed stands of xeric deciduous and coniferous woods, and in ne Plantations. In the Central Plain and Northern Highland this species is ost common in medium-aged Northern Hardwood Forest, Jack Pine rren, and Pine Plantations.

mmon Nighthawk (*Chordeiles minor*)

atus: Regular migrant and nesting species.

gration: Common spring and locally abundant fall migrant throughout Valley. Spring migrants arrive 5–10 May and peak abundance occurs May to 5 June. Fall migration begins with flock formation in early gust. Peak abundance occurs between 15 August and 1 September and parture by 20 September (latest—7 October 1973 and 8 October 1965, shington County).

Nesting Season Distribution: A common nesting species in cities and town less common and more localized in areas away from human habitation.

Habitat: This species has adapted well to expanding human population. I cities and towns, an abundance of flat roofs and gravel roadways provi excellent breeding habitat. Although nesting habitat away from huma habitation is poorly known, most birds are found associated with mixe deciduous-coniferous forest with sandy soils and open (or barren) unde story.

FAMILY APODIDAE: Swifts

Chimney Swift (*Chaetura pelagica*)

Status: Regular migrant and nesting species.

Migration: Chimney swifts are common to locally abundant in the Weste Upland and Central Plain, fairly common in the Northern Highland. Becau of their relationship with human settlements, this species is most frequent observed near villages and cities. Spring migrants begin to arrive abo 30 April and peak abundance occurs 10–20 May. Fall migrants begin t form loose flocks during late July. Peak fall migration occurs betwee 25 August and 10 September and departure by 20 September (latest- 5 October 1947).

Nesting Season Distribution: Breeding chimney swifts have been recorde in all counties of the Valley. Largest breeding populations occur in t Western Upland and Central Plain, where human habitation provides a abundance of nesting sites. Jackson (1942) reported that chimney swift occurred regularly in the northern regions, even in areas removed fro human settlement.

Habitat: Chimney swifts are most numerous in villages and cities whe they nest in chimneys and abandoned buildings. Populations of breedin chimney swifts occur in the forested regions where they occupy hollow tree (Jackson 1942) and other natural cavities for nesting.

FAMILY TROCHILIDAE: Hummingbirds

Ruby-throated Hummingbird (*Archilochus colubris*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant throughout the Valley. Spring migrant arrive during the second week of May (earliest—13 April 1953, Burnet County) and peak abundance occurs 20 May to 1 June. Peak fall abundanc occurs 10–25 August and departure by 20 September (latest—1 Octobe 1947, St. Croix County; Robbins 1948*a*).

Nesting Season Distribution: The ruby-throated hummingbird is a fairl common nesting species throughout the Valley; positive or inferred breedin s been recorded in all counties.

abitat: Breeding ruby-throated hummingbirds occur in a variety of habitat pes, most commonly in brushy margins, openings of deciduous forests, d Deciduous Clear Cuts in the Central Plain and Northern Highland. I ve found several hummingbird nests in the branches of cottonwoods along e Willow River in St. Croix County. Jackson (1942) noted that in northestern Wisconsin this species seemed to prefer tamarack bogs for nesting. e speculated that the abundant *Usnea* moss that grows on tamarack was portant for nest building.

ufous Hummingbird (*Selasphorus rufus*)

atus: Accidental, one record.

cord: One rufous hummingbird was observed in Washington County, out 3.2 km west of Prescott, Wisconsin, from the end of September to October 1978 (Binder 1979). This was one of three rufous hummingbirds at occurred in Minnesota during the late summer and fall 1978.

MILY ALCEDINIDAE: Kingfishers

lted Kingfisher (*Megaceryle alcyon*)

tus: Regular migrant, nesting species, and winter resident.

gration: Common migrant throughout the Valley. Apparent increases in ulations begin about 1 April and peak abundance occurs 10–25 April. ak fall migration occurs 10 September to 1 October and most depart by November.

sting Season Distribution: The belted kingfisher is a fairly common ting species throughout the Valley. Probably most abundant in the tral Plain and Northern Highland where there is an abundance of lakes, rs, and streams.

ater: An uncommon early winter resident north to Burnett and Pine coun-; rare after mid-January. Belted kingfishers are uncommon throughout winter in Washington, St. Croix, and Pierce counties, where fast-moving ams provide ample open water for fishing.

itat: Usually found near permanent lakes and streams that support fish ulations. Nests are usually in steep banks adjacent to streams. One nest erved in western St. Croix County was in the bank of a sandstone outpping about 2 km from the nearest water.

MILY PICIDAE: Woodpeckers

nmon Flicker (*Colaptes auratus*)

tus: Regular migrant, nesting species, and winter resident.

Table 3. *Mean number of woodpeckers, flycatchers, and swallows recorde on western Wisconsin Breeding Bird Survey transects, 1966–78.*

	Western Upland	Central Plain		Northern Highland	
Species group	Hudson	Dresser	Loraine	Union	Minon
Woodpeckers					
Common flicker	7.1	5.8	7.6	1.9	3.2
Pileated woodpecker	0.0	0.3	1.4	0.8	0.5
Red-bellied woodpecker	0.0	0.6	1.1	0.0	0.0
Red-headed woodpecker	3.4	3.5	3.8	0.5	0.0
Yellow-bellied sapsucker	0.0	0.0	1.4	<0.1	1.1
Hairy woodpecker	1.2	0.6	1.8	1.2	1.0
Downy woodpecker	1.2	0.9	3.3	1.8	1.8
Flycatchers					
Eastern kingbird	5.0	4.9	5.1	4.7	5.0
Great crested flycatcher	6.4	7.2	13.1	19.9	11.0
Eastern phoebe	1.2	0.8	2.4	2.0	2.8
Yellow-bellied flycatcher	0.0	0.0	0.0	0.0	0.1
Willow flycatcher	<0.1	0.0	0.4	0.0	0.0
Alder flycatcher	0.0	0.4	1.2	0.0	4.8
Least flycatcher	<0.1	0.7	5.4	6.0	12.7
Eastern wood pewee	1.9	2.0	6.1	15.4	8.5
Swallows					
Tree swallow	2.4	4.5	8.4	4.7	13.0
Bank swallow	13.8	3.9	6.7	0.0	0.0
Rough-winged swallow	2.7	3.4	3.3	0.0	0.1
Barn swallow	17.3	18.5	18.2	1.2	3.4
Cliff swallow	3.4	4.8	11.5	0.0	8.1
Purple martin	4.7	25.3	11.5	3.2	6.0

Migration: Common to locally abundant migrant throughout the Vall Noticeable spring movements are observed by 15–25 March. Spring grants usually travel in small scattered groups; consequently, few lar concentrations are observed. Fall migration begins in late August with d persal of young from the nesting areas. Peak fall migration occurs 15 Se tember to 10 October and most depart by 1 November. During peak mo ments in fall migration, groups of 40–50 individuals are common, wi groups totaling 100 occasionally observed.

Nesting Season Distribution: Breeding Bird Survey data show that t common flicker is the most common and well-distributed breeding woc pecker in the Valley (Table 3). Goddard (1972) found the common flicker t most abundant breeding woodpecker in the Kinnickinnic River Valle Pierce County. Nesting has been observed in all counties in the Valley.

Winter: Common flickers are rare and local winter residents in the Weste Upland and rare or absent in other regions (Table 4). Wintering individua are occasionally recorded as far north as Burnett and Pine counties.

able 4. *Relative abundance of various birds on St. Croix River Valley Christmas Bird Counts. Values presented are the mean number of birds per party hour.*

	Western Upland			Northern Highland	
pecies groups	Afton	Suburban St. Paul	New Richmond	Grantsburg	Solon Springs
Voodpeckers					
Common flicker	<0.1	<0.1	<0.1	<0.1	0.0
Pileated woodpecker	0.2	<0.1	<0.1	<0.1	<0.1
Red-bellied woodpecker	0.6	0.2	0.2	<0.1	0.0
Red-headed woodpecker	<0.1	<0.1	<0.1	<0.1	0.0
Hairy woodpecker	1.2	0.5	0.3	0.3	0.3
Downy woodpecker	1.8	0.8	0.6	0.4	0.2
Black-backed three-toed woodpecker	0.0	0.0	0.0	0.0	<0.1
orvids					
Blue jay	6.8	3.1	5.8	3.7	2.7
Common raven	0.0	0.0	0.0	0.1	4.8
Common crow	12.2	3.6	8.1	2.5	0.8
rids and nuthatches					
Black-capped chickadee	8.0	4.2	2.8	2.1	2.7
Tufted titmouse	0.2	<0.1	0.0	0.0	0.0
White-breasted nuthatch	2.8	1.7	1.0	0.7	0.3
Red-breasted nuthatch	0.1	<0.1	0.0	<0.1	0.3
lected finches and sparrows					
ardinal	3.1	0.7	0.8	0.1	0.0
vening grosbeak	0.5	0.3	0.8	8.3	3.3
urple finch	2.2	0.4	0.2	<0.1	<0.1
ine grosbeak	0.2	0.1	0.0	0.2	4.6
ommon redpoll	4.5	7.6	6.7	6.8	16.7
ine siskin	4.0	0.9	0.5	0.7	0.3
merican goldfinch	4.1	2.7	3.1	2.3	0.2
ark-eyed junco	8.9	3.2	2.5	0.2	<0.1
ree sparrow	6.9	2.0	4.9	0.3	0.0

H itat: Common flickers are characteristic of the Southern Deciduous F est, reaching greatest densities in medium-aged oak forest. Fairly co mon breeding species in Northern Hardwood Forest and Pine Barrens. U ommon to rare in other habitat types.

Pi ated Woodpecker (*Dryocopus pileatus*)

St us: Regular permanent resident.

Distribution: Uncommon to fairly common resident in all regions of e Valley; most numerous along the St. Croix River and its major tributar s. Because of large breeding territories and relative scarcity, low numbers f this woodpecker are recorded along BBS transects (Table 3). All five surv y routes traverse fair to good habitat, yet this woodpecker is recorded in v y low numbers.

Winter: Winter distribution of this woodpecker is presented in Tabl . Largest winter populations occur in the Western Upland. The pileated wo pecker is fairly regular during winter in Burnett, Douglas, and P e counties where a combination of Northern Hardwood Forest and conifer s forest provides optimum habitat.

Habitat: The pileated woodpecker is characteristic of large expanses of e mature Lowland Deciduous Forest along and adjacent to the St. Cr x River. Fairly common in mature Upland Hardwood Forest and Lowla d Coniferous Forest. Uncommon to rare in Southern Deciduous Forest. R e to absent in other habitat types.

Red-bellied Woodpecker (*Melanerpes carolinus*)

Status: Regular permanent resident.

Distribution: Fairly common breeding bird in the Western Upland, u common to rare in the Central Plain, and rare to absent in the Northe Highland. The red-bellied woodpecker is a southern species that reaches northern range limit along the St. Croix River (Peterson 1951).

Breeding Bird Survey data show that red-bellied woodpeckers occur reg larly in central Polk County. Occasional birds with young are observ in Burnett and southern Pine counties. Hamerstrom and Hamerstrom (19 include two confirmed nest records from along the St. Croix River in weste Burnett County. Movement into the northern regions must be fairly rece since Jackson (1942) failed to record this species in 1919 during his work northwestern Wisconsin. Bernard (1967) considered this species to be ve rare in Douglas County, citing three observations in areas north of the S Croix River. Green and Janssen (1975) cited documented breeding recor for Washington County and showed red-bellied woodpecker breeding ran extending north to the Chisago–Pine county line.

Winter: Locally a fairly common winter resident in the Western Upland, ra and local adjacent to the St. Croix River in the Central Plain (CBC; Table 4

Habitat: This woodpecker is a characteristic species of Lowland Deciduo Forest. Large expanses of lowland forest occurring along the St. Croix Riv and its major tributaries provide excellent breeding habitat. During th breeding season, pairs also use the edge between lowland forest and Sout ern Deciduous Forest and locally in Northern Hardwood Forest. Winterin birds are found primarily in Lowland Deciduous Forest and Southern Deci uous Forest. This woodpecker is attracted to corncribs on farms near woo land edges during the winter.

Red-headed Woodpecker (*Melanerpes erythrocephalus*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Fairly common spring and fall migrant in the Western Upland and Central Plain. Uncommon and more sporadic in the Northern Highland. The first noticeable influx of spring migrants occurs 20 April to 1 May, reaching peak numbers 15–25 May. Fall migration begins about 10 August in the Northern Highland and 20 August elsewhere. Peak movements occur 25 August to 15 September and most have departed by 1 November.

Nesting Season Distribution: Fairly common breeding species in the Western Upland and Central Plain, rare to uncommon in the Northern Highland. Breeding Bird Survey Data indicate that a uniformly distributed breeding population occurs through the Western Upland and Central Plain (Table 3). Evidence of nesting or the presence of inferred nesting records have been obtained in all counties of the Valley.

Winter: Uncommon and local winter resident in upland oak habitat near the St. Croix River. The CBC data (Table 4) indicate that red-headed woodpeckers occur regularly north to Burnett and Pine counties in winter. Moe (1968) also showed that the winter distribution of red-headed woodpeckers in Wisconsin extended northward including southeastern Burnett County.

Habitat: Breeding red-headed woodpeckers occupy both upland and lowland deciduous forests. Largest breeding densities occur in mature Southern Deciduous Forest in the Western Upland. This woodpecker also uses second growth oak forest and open-oak forest extensively. Mature Lowland Deciduous Forest that is dominated by green ash and American elm is also an important breeding habitat. Suitable breeding habitat is enhanced by the presence of dead or dying trees. The spread of oak-wilt and dutch elm disease has aided in providing additional nesting sites for these birds.

Yellow-bellied Sapsucker (*Sphyrapicus varius*)

Status: Regular migrant and nesting species, casual in winter.

Migration: Uncommon spring and fall migrant in all regions. Spring migrants begin to arrive 25 March to 5 April and peak migration occurs 15 April to 1 May. Fall migration begins 15–25 August. Peak numbers occur 20 September to 5 October and departure by 25 October.

Nesting Season Distribution: Uncommon to fairly common breeding bird in the Northern Highland, uncommon in the Central Plain, rare and local in the Western Upland. Documented nesting records exist for all counties in the Valley.

Winter: Yellow-bellied sapsuckers have been observed twice on the Afton CBC, Washington County: 2 January 1960 and 1 January 1970 (at a feeding station).

Habitat: Yellow-bellied sapsuckers occupy a variety of upland deciduous and coniferous forest types for nesting. This species is most common during the breeding season in climax or near climax Northern Hardwood Forest that is dominated by maple and basswood. Nesting also occurs in matu and second growth aspen-maple forest. Coniferous forests are used to lesser extent for nesting. Breeding yellow-bellied sapsuckers regularly u extensive stands of Lowland Deciduous Forest in the Western Upland.

Hairy Woodpecker (*Picoides villosus*)

Status: Regular permanent resident.

Distribution: Fairly common breeding bird in the Northern Highland a Central Plain, uncommon and local in the Northern Highland. Godda (1972) reported a breeding density of 3.45 pairs per 40 ha in the Kinnickinn River Valley, Pierce County. Breeding Bird Survey data (Table 3) sugge that breeding densities are fairly uniform throughout the Valley.

Winter: Fairly common winter resident in the Western Upland and Centr Plain; uncommon in the Northern Upland. The CBC data (Table 4) show t greatest densities occurring along and adjacent to the lower St. Croix Rive The largest count was 91 on the Afton CBC, 1 January 1972.

Habitat: Hairy woodpeckers are not indicative of any one habitat typ Breeding pairs occupy a variety of habitats including Lowland Deciduou Forest, Southern Deciduous Forest, Northern Hardwood Forest, a Lowland Coniferous Forest.

Downy Woodpecker (*Picoides pubescens*)

Status: Regular permanent resident.

Distribution: Fairly common in the Western Upland, common in the Centr Plain and Northern Highland. Breeding Bird Survey data (Table 3) sugge that the breeding population increases slowly northward across the Valle Jackson (1942), however, noted that the downy woodpecker was usually le numerous than the hairy woodpecker in northern Wisconsin. Goddard (197 reported a breeding density of 6.6 pairs per 40 ha in the Kinnickinnic Riv Valley, Pierce County.

Winter: Common winter resident in the Western Upland, fairly common the Central Plain and Northern Highland. The mean ratio of downy to hai woodpeckers in the Valley during winter is 1.5 to 1.0. Only in the Northe Highland does the hairy woodpecker appear to be more numerous than t downy woodpecker. Young (1961) also noted a greater proportion of hai woodpeckers to downy woodpeckers in northwestern Wisconsin. Large winter counts were 143 on the Afton CBC, 1 January 1972 and 123 on t Suburban St. Paul CBC, 2 January 1976.

Habitat: Habitat use by the downy woodpecker is characterized by bot upland and lowland coniferous and deciduous forests. Edge situations a used more extensively by this species than by the hairy woodpecker, esp cially for feeding. During winter, downy woodpeckers occupy habitat simil to that used for breeding. In agricultural areas, downy woodpeckers also u corn stubble fields regularly for feeding.

k-backed Three-toed Woodpecker (*Picoides arcticus*)

us: Regular migrant, nesting species, and winter resident.

ation and Winter: Casual fall migrant and winter resident in all regions. s for Washington County include 28 October 1964 at Stillwater (Honet- ger 1965), 2 November 1972, and 14 January 1973 (Huber 1974*b*). This lpecker was observed once in Chisago County on 13 November 1966, in Pine County on 28 February 1974 (Eckert 1974). Wisconsin records de Polk County, 23 December 1974 at the McKenzie Creek Wildlife (T. 37 N., R. 16 W.); Thiel (1978) lists three winter records for Polk ty, although he provides no dates or locations. Douglas County records de one bird 9.6 km west of Solon Springs (Sec. 36, T. 45 N., R. 15 W.) on ovember 1974. One was observed on the Solon Springs CBC on 23 De- er 1976 (Table 4).

ng Season Distribution: Rare and local permanent resident of the North- ighland. Bernard (1967) considered this woodpecker a "rare permanent ent that nests locally" in Douglas County. The nesting areas that Ber- refers to occur along the Brule River. The only evidence of nesting in alley is provided by Knudson (1978). On 3 August 1978, Knudson ob- d three black-backed three-toed woodpeckers that he considered to be emale and two immatures in T. 43 N., R. 13 W., Douglas County. On 21 August 1978, Jeffery Knudson observed a male at the same location. dson speculated that this was a nesting record.

tat: The habitat associated with most black-backed three-toed wood- ers observed during the breeding season is predominantly Lowland ferous Forest. Coniferous trees killed by fire are particularly attractive is species. Although Knudson (1978) found adult and immature birds Jack Pine Barrens, this habitat may have been used only as feeding at and not for nesting. This species is found in the extensive Lowland ferous Forest of Burnett, Douglas, and Pine counties. Additional field in Lowland Coniferous Forest directly adjacent to the St. Croix River shed more light on the breeding status of this species.

thern Three-toed Woodpecker (*Picoides tridactylus*)

us: Casual winter visitor.

rds: The first bird was observed by K. H. Dueholm on 8 March 1975 in County, and subsequently on 15 March 1975 (Faanes 1975). This bird using a small Black Spruce–Tamarack Bog (Sec. 12, T. 34 N., R. 16 W.). lugow (personal communication) observed a second northern three-toed lpecker in Polk County (Sec. 3, T. 33 N., R. 15 W.) on 11 April 1976.

MILY TYRANNIDAE: Tyrant Flycatchers

tern Kingbird (*Tyrannus tyrannus*)

us: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants retu to the Western Upland 30 April to 5 May and reach the Northern Highla by 10 May (earliest—11 April 1954, Crex Meadows, Burnett County). Pe spring migration occurs 10–25 May and most birds are on nesting territor by 1 June. Fall migration begins in early August. Peak fall populatio occur 20 August to 1 September and departure by 15 September (lates 2 October 1969, Chisago County).

Nesting Season Distribution: Common breeding species in all regions. C firmed breeding records exist only for Pierce, Polk, and St. Croix count Inferred nesting exists for the remaining counties. Breeding Bird Sur data (Table 3) indicate that an unusually uniform and well-distributed bre ing population exists within the Valley.

Habitat: Eastern kingbirds use edge habitats probably more than any ot r flycatcher. Characteristics of typical eastern kingbird breeding habi t include woodlots, scattered clumps of tall shrubs, fencelines, open fields, d edges of sedge meadows. Fences and transmission lines are apparently portant components of breeding habitat and are used extensively as hunt g perches. Jackson (1942) found eastern kingbirds "especially abundant" n Jack Pine Barrens and regrown burned areas in northwestern Wisconsin.

Western Kingbird (*Tyrannus verticalis*)

Status: Casual migrant and nesting species.

Migration: Rare spring and fall migrant. Records are too few to determ e average dates of arrival or departure. However, most observations oc r 15 May to 1 September. Migrants have been recorded from Burnett, t. Croix, and Washington counties.

Nesting Season Distribution: Rare nesting species in St. Croix Coun . Nesting was first reported in 1961 when a pair was successful at Hudson pair returned to the same site each year until 1971 when small boys shot e pair from the nest. During the summer of 1967, Peter Tweet found an ad tional breeding pair near Burkhardt, in west central St. Croix County. Ad tional breeding season records include a single bird at Crex Meadows, B nett County, on 27 July 1953, 11 and 26 July, and 5 August 1956. In Min sota, two young were observed at Langdon, Washington County, n 13 August 1952 (Lupient 1952). In St. Croix County, western kingbirds w e not recorded again until I observed a group of four near New Richmond n 16 August 1975. This group remained in the same area until 25 August. e next record was obtained on 19 August 1976, when a single bird was fou d in the same area. This individual remained in the area until 26 August 197

Habitat: The Hudson breeding pair was located in a residential area. Ot r records of breeding pairs are associated with edge habitats in agricultu l areas.

Great Crested Flycatcher (*Myiarchus crinitus*)

Status: Regular migrant and nesting species.

gration: Uncommon to fairly common migrant throughout the Valley, ally common along the lower reaches of the St. Croix River. Spring mi- ints generally arrive about 1 May in the Western Upland and 5-10 May the Northern Highland. Peak abundance occurs 15-30 May. Fall migra- n begins in mid-August, reaching peak abundance by 1 September. Mi- ints have departed the Northern Highland by 15 September and the nainder of the region by 25 September.

sting Season Distribution: Uncommon nesting species in the Western land and Central Plain, fairly common to locally common in the Northern ghland. Breeding Bird Survey data (Table 3) suggest a gradual increase in eding densities moving northward through the Valley. However, Jackson 42) recorded great crested flycatchers as "never more than two seen at a ality . . ." in the Northern Highland. Goddard (1972) found this flycatcher be among the 12 most numerous breeding birds along the Kinnickinnic er Valley in Pierce County. Nesting has been confirmed only in St. Croix unty where I observed a nest along the Willow River on 10 June 1975. Al- ugh only one nest has been confirmed, inferred nesting records have been ained in the remaining counties.

bitat: The great crested flycatcher is a forest species, generally asso- ted with the upper canopy of medium-aged to mature deciduous forest. e only confirmed nesting record was obtained from a mature Lowland ciduous Forest where cottonwood was the predominant tree species. irs are commonly recorded in extensive stands of Northern Hardwood rest and in Southern Deciduous Forest. Use of residential habitats has o been recorded.

stern Phoebe (*Sayornis phoebe*)

tus: Regular migrant and nesting species.

gration: Fairly common migrant throughout the Valley. Eastern phoebes among the first passerines to return in the spring; the first migrants ive in the Western Upland 20-25 March. Although most observations isist of pairs on breeding territories, a peak in spring migration is appar- 15-25 April. Fall migration begins in mid-August and peak movements ur 5-15 September. Late departure dates range from 1-5 October in the rthern Highland to 20 October in the Western Upland.

sting Season Distribution: Fairly common nesting species in all regions l documented nesting records exist from each county. Breeding Bird vey data (Table 3) indicate a fairly evenly distributed breeding popu- on. Jackson (1942) considered the eastern phoebe to be a very common eding bird along the St. Croix River. Goddard (1972) reported a density 9.1 breeding pairs per 40 ha in the Kinnickinnic River Valley, Pierce inty.

bitat: Eastern phoebes are attracted to a variety of edge situations, pri- rily woods-field border and streamside habitats. During the nesting son, eastern phoebes are usually associated with bridges, culverts, or er man-made structures, sheer cliffs, and rocky outcroppings.

Yellow-bellied Flycatcher (*Empidonax flaviventris*)

Status: Regular migrant, one nesting record.

Migration: Uncommon spring migrant in the Western Upland and Central Plain, locally common in the Northern Highland. Fairly common to locally common fall migrant in all regions. Earliest spring migrants arrive 10–15 May, reaching the Northern Highland about 20 May. Peak migration occurs 20–30 May and departure from most areas by 5 June. Fall migration begins by mid-August (earliest—31 July 1967, Washington County). Peak movements occur 15 August to 1 September and birds depart by 15 September.

Nesting Season Distribution: Bernard (1967) cited the only known nesting record for the region, a nest with four eggs near Wascott (Douglas County) on 21 July 1941. Green and Janssen (1975) cited the observation of singing males near Bruno, Pine County. I observed singing males along the St. Croix River near Gordon, Douglas County, on 20 July 1976, and again on 10 June 1977. In neither instance were nests observed. The yellow-bellied flycatcher is probably more widespread as a nesting species than available records indicate because of the vast amount of suitable nesting habitat in the Northern Highland.

Habitat: The 1976 and 1977 records were obtained from an extensive stand of black spruce–tamarack swamp adjacent to the St. Croix River. At other seasons, this flycatcher regularly uses a variety of edge situations.

Acadian Flycatcher (*Empidonax virescens*)

Status: Casual migrant and possible nesting species.

Records: Observations of this bird at the northern limit of its range have been sporadic. Because of their occurrence during normal nesting periods, this species must be considered a possible nesting bird. St. Croix County records include 12 May 1974 at Roberts, and 15 May 1973, 21 June to 5 July 1963, and 22 July 1965 at Hudson. One record exists of this species in the Minnesota Counties. Bratlie (1976) described observations at Franconia, Chisago County, on 8 and 16 June 1976.

Habitat: A species of deciduous forest habitats including Lowland Deciduous Forest and heavily wooded hillsides in mesic Southern Deciduous Forest.

Willow Flycatcher (*Empidonax traillii*)

The decision of the American Ornithologists' Union (AOU 1973) to split the Traill's flycatcher (*Empidonax traillii*) into two separate species created many problems in range delineation. Before that time, both willow and alder flycatchers were recorded as one species, even though song and habitat differences were readily apparent. Fortunately, S. D. Robbins maintained separate records of both species based on song, and from his work it is possible to aw conclusions on the range of these two species in Wisconsin (Robbins 74*b*). Because this work was not carried out in Minnesota, only general- d distribution can be provided for that State.

atus: Regular nesting species.

igration: Most records of this species are of breeding pairs on territory. nsequently, dates of first occurrence are nearly impossible to determine. e earliest record I have of a singing willow flycatcher is 20 May 1974 in . Croix County. This date is near the usual range of 10–20 May for the ival of most *Empidonax* flycatchers in the Valley. Fall departure obably begins in early August and most birds have left by 15 September. cause nearly all *Empidonax* flycatchers are silent in the fall, few data ist on their migration.

sting Season Distribution: Robbins (1974*b*) cited summer records of this ecies in St. Croix County in 1961–67 and 1970. There are Polk County cords in 1965–67 and 1970 and Pierce County records for 1965–78. S. D. bbins (personal communication) found a singing male willow flycatcher ar Fish Lake, Burnett County, on 17 June 1978 and 22 June 1977. I ob- ved male willow flycatchers on territory in Washington County near Still- ter on 6 July 1978. Breeding Bird Survey data were not separable to ecies until 1975. Consequently, only recent survey data from the Loraine nsect in Polk County provide information on relative abundance ble 3). One nesting record exists for the region. I found a nest with four gs along Black Brook, Cylon Township, St. Croix County, on 9 July 1978.

bitat: Willow thickets and Shrub Carr associations are the primary bitats of this bird. The St. Croix County nest was placed in a young black low located in an extensive Shrub Carr. Observations of singing males are ariably associated with these wetland types.

der Flycatcher (*Empidonax alnorum*)

atus: Regular migrant and nesting species.

gration: Observations of alder flycatchers during spring are usually pairs presumed breeding territories. Song dates of first observation usually ur 15–20 May in the Western Upland and about 20 May in the Northern ghland. Alder flycatchers are apparently most numerous 20 May to une. Fall migration begins in mid-August, reaching peak numbers 10 September. Departure of this species occurs 15–20 September.

sting Season Distribution: Fairly common to locally common nesting cies north of the Tension Zone. Within this zone of overlap, observations reeding pairs have been made in southern Washington and northwestern rce counties. Breeding Bird Survey data (Table 3) indicate that the gest breeding populations occur north of the Tension Zone. Documented ting records exist for Polk and Douglas counties. Faanes and Goddard 76) cited observations of singing males 15–20 June in northern St. Croix unty.

bitat: Alder flycatchers use a greater diversity of habitat types than is used by the preceding species. Nests in Polk County were in Alder Thick habitat where speckled alder was the predominant shrub species. Elsewhe breeding pairs have been recorded in Northern Hardwood Forest, Bla Spruce–Tamarack Bogs, and Deciduous Clear Cuts.

Least Flycatcher (*Empidonax minimus*)

Status: Regular migrant and nesting species.

Migration: Common to locally abundant migrant in all regions, reachi largest numbers in the Central Plain and Northern Highland. Spri migrants arrive in the Western Upland 1–5 May and the Northern Highla by 10 May. Peak abundance occurs 15 May in the Western Upland 20 May in the north. Fall migration begins in early August. Peak fall mig- tion occurs 20 August to 1 September in the north and 25 August to 5 S- tember elsewhere. Departure from the Northern Highland occurs 10–15 S- tember and elsewhere by 30 September (latest—5 October 1974, St. Cro County).

Nesting Season Distribution: Common to locally abundant nesting spec in all regions. Goddard (1972) reported a breeding density of 8.1 pairs p 40 ha in the Kinnickinnic River Valley, Pierce County. Confirmed nesti records exist only for Polk County; inferred nesting has been documented all other counties. Breeding Bird Survey data (Table 3) indicate that lea flycatcher breeding populations apparently increase in abundance movi northward through the Valley, reaching peak density in the Northern Hi- land. Jackson (1942) reported that the least flycatcher was the most ab- dant flycatcher in Polk and Burnett counties.

Habitat: Primarily an edge species; nesting season least flycatchers a usually recorded in a variety of habitat types. Western Upland breedi birds are usually associated with medium-aged Southern Deciduous For and mature Lowland Deciduous Forest. Central Plain and Northern Hi- land birds are typically recorded in mature Northern Hardwood Fore Deciduous Clear Cut, and mixed coniferous–deciduous forest. In the Ja Pine Barren regions of the Central Plain, breeding pairs are usually as- ciated with deciduous habitats along streams rather than jack pines.

Eastern Wood Pewee (*Contopus virens*)

Status: Regular migrant and nesting species.

Migration: Eastern wood pewees are among the latest arriving flycatch in this region, usually not observed until after 15 May (earliest—26 Ap 1974, Burnett County), and peak migration occurs 20–30 May. Fall mig- tion begins about 5 August in the Northern Highland and 15 August el- where. Peak migration occurs 20 August to 1 September and departure 25 September (latest—27 September 1976, Washington County).

Nesting Season Distribution: Fairly common nesting species in all region the Valley. Confirmed nesting has been documented in St. Croix a

Douglas counties with inferred nesting elsewhere. Breeding Bird Survey data (Table 3) indicate that a fairly uniform breeding population occurs in the Western Upland and Central Plain. Relative abundance increases markedly north of that zone. Goddard (1972) found this species to be the sixth most abundant breeding bird along the Kinnickinnic River in Pierce County. The mean breeding density in that area was 27.4 pairs per 40 ha.

Habitat: The eastern wood pewee is characteristic of mature deciduous orest. In the Western Upland, breeding pairs are generally associated with mature Lowland Deciduous Forest and occasionally with mature Southern Deciduous Forest. Central Plain and Northern Highland populations are apparently most numerous in mature Northern Hardwood Forest.

Olive-sided Flycatcher (*Nuttallornis borealis*)

Status: Regular migrant and nesting species.

Migration: The olive-sided flycatcher is among the latest arriving songbirds. Average date of spring arrivals in the Western Upland is 16 May and arrivals in the Northern Highland are during 20–25 May. Dates of peak abundance are not provided, primarily because this bird migrates singly or in small groups. Consequently, very few individuals are recorded daily during periods when they would be expected to be numerous. Migrants have usually departed nonbreeding areas by 1 June (latest—11 June 1974, Pierce County). Fall migrants arrive in the Western Upland during early August and become most conspicuous 20–30 August. Departure from northern nesting areas occurs about 5 September and departure elsewhere by 20 September.

Nesting Season Distribution: The only confirmed evidence of nesting is provided by Green and Janssen (1975) who listed a nest record from Sturgeon Lake, Pine County. Considerable inferred breeding evidence exists for northern Burnett and southern Douglas counties where this bird is an uncommon and local summer resident. Although nests have not been observed, extensive stands of black spruce–tamarack habitat along the St. Croix River in Burnett, Douglas, and Pine counties usually support breeding season adults.

Habitat: Olive-sided flycatchers are characteristic of boreal forest habitat during the nesting season. Extensive stands of Lowland Coniferous Forest, combined with an interspersion of open areas of sphagnum moss provide deal breeding habitat. Also frequently used are white cedar swamps. One actor that characterizes olive-sided flycatcher habitat is the presence of dead snags that are used for feeding and singing perches.

FAMILY ALAUDIDAE: Larks

Horned Lark (*Eremophila alpestris*)

Status: Regular migrant and nesting species, casual winter resident.

Migration: Common to abundant migrant throughout the Valley. Th
largest numbers occur in open agricultural regions of the Western Uplan
and Central Plain. Spring migration begins during late January in the sout
and the first migrants reach Burnett and Pine counties by 15 Februar
Peak spring migration occurs between 25 February and 25 March. Peak fa
migration occurs between 15 October and 10 November and most have d
parted by 15 December.

Nesting Season Distribution: Horned larks are common nesting birds in th
Western Upland and Central Plain, rare and local in the Northern Highland

Winter: During the winter, horned larks present a perplexing problem i
determining whether individuals are early or late migrants or actual winte
residents. North of St. Croix Falls, this species is generally absent from mi
December to late January. South of St. Croix Falls, occasional small flock
of 5 to 20 individuals can be found in open areas during this period. I usuall
consider displaying individuals to be returning summer residents and co
sider migration to be commencing with the observation of the first larg
flocks.

Habitat: Horned larks are characteristic of agricultural areas. Breedin
densities appear largest in short vegetation associated with domestic ha
fields and oat stubble. This species has adapted well to man's increased agr
cultural production and breeding pairs regularly use bare cultivated field
and various row-crop fields.

FAMILY HIRUNDINIDAE: Swallows

Tree Swallow (*Iridoprocne bicolor*)

Status: Regular migrant and nesting species.

Migration: Abundant migrant in all regions. Spring migrants arrive in th
Western Upland 25 March to 5 April and reach the Northern Highlan
5–10 April. Peak spring abundance occurs 20–30 April. Fall migratio
begins in late July with flocking of family groups. Peak fall abundanc
occurs 15–30 August and departure by 10 October. During peak fall migra
tion, tree swallows are occasionally observed in massive mixed-specie
flocks near large water bodies. Concentrations of 4,000 to 5,000 individual
are frequently observed along the lower St. Croix River.

Nesting Season Distribution: Common nesting species in the Wester
Upland and Central Plain, common and more local in the Northern High
land. Breeding Bird Survey data (Table 3) show that tree swallows are uni
formly distributed throughout the Valley.

Habitat: Tree swallows nest in loose, semicolonial associations. Breeding
pairs are typically associated with water bodies that are normally near smal
groves of trees (Western Upland and Central Plain) or along northern Forest
Bordered Lakes. Extensive use is made of the edge between deciduous forest
and natural openings or agricultural fields. Nests are normally located in
natural cavities in tree stumps or fence posts and occasionally in holes in

stream banks. Tree swallows have benefited by exploiting the large number of eastern bluebird houses that have been placed in agricultural areas and near residential areas.

Bank Swallow (*Riparia riparia*)

Status: Regular migrant and nesting species.

Migration: Common spring and fall migrant throughout the Valley. Spring migrants arrive in the Western Upland 15–20 April and reach the Northern Highland 20–25 April. Peak abundance occurs between 25 April and 15 May. Fall migration begins during mid-July. Peak abundance through the Valley occurs between 25 July and 5 August, and departure by 5 September.

Nesting Season Distribution: Common nesting species throughout the Western Upland and Central Plain becoming uncommon to rare and local in the Northern Highland. Breeding Bird Survey data (Table 3) show that the breeding distribution of this swallow is restricted primarily to areas that are not heavily forested.

Habitat: Breeding bank swallows are associated with natural banks along rivers, streams, and lakes. Gravel pits and roadside banks that were exposed during highway construction are also heavily used. Colonies are frequently associated with open agricultural areas that are used extensively for foraging.

Rough-winged Swallow (*Stelgidopteryx ruficollis*)

Status: Regular migrant and nesting species.

Migration: Common migrant in the Western Upland and Central Plain, north to Grantsburg, Burnett County; rare and local elsewhere. Spring migrants arrive 15–25 April and peak abundance occurs 25 April to 5 May. Fall migration begins in late July with gathering of family groups. Peak abundance occurs between 25 July and 10 August and departure by 1 September.

Nesting Season Distribution: Fairly common (locally abundant) breeding species in the Western Upland and Central Plain, rare to absent in heavily forested regions. Breeding Bird Survey data suggest that this species is the least common of the swallows nesting in the Valley. However, Goddard (1972) found rough-winged swallows among the 10 most abundant breeding bird species along the Kinnickinnic River, Pierce County. Average breeding density in that area was 26.5 pairs per 40 ha. This exceptionally high density results from the numerous exposed limestone cliffs along that river, which provide abundant nesting sites.

Habitat: Breeding rough-winged swallows are usually associated with exposed banks along rivers and streams. Particularly important are limestone cliffs along fast-moving streams and rivers in the Western Upland. Occasional use is made of artificial earthen banks and bridges over small streams.

Barn Swallow (*Hirundo rustica*)

Status: Regular migrant and nesting species.

Migration: Common spring and fall migrant throughout the Valley. Sprin migrants arrive in the Western Upland during 15–20 April reaching th Northern Highland about 25 April (earliest—11 April 1953, Burnet County). Peak abundance during spring migration occurs 5–10 May. Fa migration begins about 1 August. Peak fall abundance occurs 25 August t 10 September and departure by 10–15 October.

Nesting Season Distribution: Common nesting species in the Wester Upland and Central Plain, uncommon and local in the Northern Highlanc Breeding Bird Survey data (Table 3) suggest that the barn swallow is th most numerous breeding swallow in the Western Upland and Central Plain.

Habitat: Primarily a species of open habitats, usually associated wit human habitation. Most nests are found under bridges or on buildings.

Cliff Swallow (*Petrochelidon pyrrhonota*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley, occasionally abundan near the St. Croix River. Spring migrants arrive in the Western Uplan 1–5 May and peak abundance occurs 10–20 May. Fall migration begins i mid-August. Peak fall abundance occurs 1–10 September and departure b 25 September (latest—18 October 1974, Pierce County).

Nesting Season Distribution: Fairly common breeding species throughou the Valley. Breeding Bird Survey data (Table 3) suggest that the abundanc of the nesting population increases northward across the Valley.

Habitat: Primarily a colonial or semicolonial nesting species, utilizing barns sheds, and bridges extensively for nest placement. Occasional groups ar found nesting in natural settings, including limestone cliffs.

Purple Martin (*Progne subis*)

Status: Regular migrant and nesting species.

Migration: Common to abundant migrant throughout the Valley. Sprin migrants arrive 5–10 April and peak abundance occurs 1–10 May. Fal migration begins about 1 August. Peak abundance occurs 25 August t 1 September and departure by 20 September (latest—6 October 1966, Washington County).

Nesting Season Distribution: Common nesting species throughout th Valley. Jackson (1942) referred to the purple martin as "the most generall distributed" among the swallows in northwestern Wisconsin. Breeding Bir Survey data (Table 3) suggest that the largest densities occur in the Centra Plain.

Habitat: The purple martin is one of few species benefiting from expandin uman population. Colonial martin houses in residential and rural areas ave become vitally important to this species.

AMILY CORVIDAE: Jays, Magpies, and Crows

ray Jay (*Perisoreus canadensis*)

tatus: Casual migrant, winter and summer resident.

igration: Irregular migrant throughout the Valley. Earliest fall migration ecords include 17 October 1976 (Washington County), 25 October 1965 rex Meadows, Burnett County), and 1 November 1974 (Chisago County). ost fall observations occur 15 November to 15 December. Green (1967) decribed an invasion of gray jays in northern Minnesota that resulted in several Valley records. Spring observations range from 23 February 1957 to 0 March 1966 and 6 April 1954 (Crex Meadows, Burnett County).

esting Season Distribution: W. Norling observed one pair of gray jays in a pruce forest southwest of Moose Junction, Douglas County, on 3 July 978. On 27 June 1956, A. C. Sprunt observed several gray jays in the Koher–Peet Wildlife Area, Burnett County (Lound and Lound 1956*b*). Sprunt ound this species near Gordon, Douglas County, on 6 July 1956.

inter: Irregular winter visitor with documented records only from Burnett 1948, 1955, 1957, and 1976), Pierce (January 2, 1976) and Pine (1973 and 1976) counties. During the winter of 1956–57, gray jays were reported as numerous" near Grantsburg, Burnett County. This species is probably ore common during winter months than available data indicate, paricularly in the Northern Highland.

abitat: During migration and winter, gray jays use a variety of habitats inluding Lowland Coniferous Forest, Northern Hardwood Forest, and Jack ine Barren. Summer observations have been restricted to extensive areas f Lowland Coniferous Forest.

lue Jay (*Cyanocitta cristata*)

tatus: Regular migrant, nesting species, and winter resident.

igration: Common to locally abundant migrant in all regions. The first igration movements in spring are usually noted about 1–5 April and peak umbers occur 25 April to 10 May. Fall migration begins in mid-August ith the formation of loose flocks. Peak movements during fall occur –15 September and most migrants have departed the Northern Highland y 15 November.

esting Season Distribution: Fairly common breeding species in the estern Upland and Central Plain, common in the Northern Highland. Godard (1972) found the blue jay to be among the 10 most common breeding irds in mixed deciduous habitat along the Kinnickinnic River, Pierce ounty. Mean breeding density in that area was 23 pairs per 40 ha. Breeding

Table 5. *Mean number of corvids, parids, wrens, mimids, and thrushes recorded on western Wisconsin Breeding Bird Survey transects, 1966–78.*

	Western Upland	Central Plain		Northern Highland	
Species group	Hudson	Dresser	Loraine	Union	Minong
Corvids					
Blue jay	4.9	9.0	11.2	29.0	19.1
Common raven	0.0	0.0	0.5	<0.1	3.2
Common crow	36.3	30.2	54.7	28.6	29.5
Parids and nuthatches					
Black-capped chickadee	0.4	0.6	2.4	7.0	8.2
White-breasted nuthatch	0.6	1.8	2.2	1.0	0.5
Red-breasted nuthatch	0.0	<0.1	0.0	0.2	0.5
Wrens					
House wren	8.9	10.4	13.3	14.8	9.0
Winter wren	0.0	0.0	0.0	0.0	0.1
Long-billed marsh wren	0.0	0.2	0.2	0.0	0.0
Short-billed marsh wren	2.5	3.7	6.4	0.0	1.3
Mimids					
Gray catbird	5.2	8.8	16.7	8.0	12.4
Brown thrasher	8.4	9.1	5.2	5.9	5.6
Thrushes					
American robin	30.5	46.1	30.6	19.8	26.9
Wood thrush	0.4	0.6	0.7	0.8	2.2
Hermit thrush	0.0	0.0	0.0	1.4	6.1
Veery	<0.1	1.4	11.2	1.2	27.1
Eastern bluebird	2.1	3.8	3.9	6.7	1.8

Bird Survey data (Table 5) demonstrate a gradual increase in abundanc northward across the Valley.

Winter: Blue jays are among the few conspicuous members of the winter avifauna in the Valley. Populations vary considerably each winter because o various environmental factors affecting habitat suitability and food supply Analysis of CBC data (Table 4) indicates that winter populations are larges in the Western Upland region where the predominant habitat is Southern Deciduous Forest. Winter populations in Jack Pine Barrens (Grantsburg CBC) are also high. Lowest winter populations occur in the mixed deciduous–coniferous forest type of the Northern Highland. Largest CBC counts include 597 (2 January 1976) and 485 (2 January 1977) on the Suburban St Paul CBC, and 509 (1 January 1970) on the Afton CBC.

Habitat: Blue jays use a variety of habitats for nesting, including deciduous and coniferous communities, edge situations, and various ornamental plantings in residential areas. Highest breeding densities occur in northern coniferous communities including Jack Pine Barren and mixed deciduous–conif rous habitats. In the Western Upland, blue jays are common in Southern Deciduous Forest and in remnants of oak savannah. This species appears to be partial to oak forest. During years of poor acorn production, the migration of this species is heavy. In years of high acorn production, large wintering populations occur.

Black-billed Magpie (*Pica pica*)

Status: Casual, two fall records and one hypothetical record.

Records: K. H. Dueholm observed a black-billed magpie at the McKenzie Creek Wildlife Area, Polk County, on 25 October 1973. C. Strehlow observed one in St.Croix County on 12 November 1921 (Milwaukee Public Museum files). Bernard (1967) described a specimen in the University of Wisconsin–Superior bird collection that was "said to have been taken at Solon Springs in the 1930's. Unfortunately, however, no label is attached to the specimen." Roberts (1932) stated that in Minnesota, the black-billed magpie occurs "as far east as Pine and Goodhue counties, both bordering on the Wisconsin line."

Common Raven (*Corvus corax*)

Status: Regular permanent resident.

Migration: Uncommon spring and fall migrant in the Northern Highland and Central Plain, accidental elsewhere. Definite migratory movements begin about 15 October, reaching a peak by 1 December. Spring migration begins in late February with dispersal from winter territories. Most ravens have reached their breeding territories by 1 April.

Nesting Season Distribution: Breeding Bird Survey data suggest that the common raven is a rare breeding bird in the Central Plain and uncommon in the Northern Upland (Table 5). Documented nest records exist only for Burnett and Polk counties. Jackson (1942) failed to record ravens during his research in northwestern Wisconsin in 1919. Bernard (1967) considered common ravens uncommon in summer, but cited no evidence of breeding.

Winter: Fairly common to common winter resident in the Northern Highland, uncommon to fairly common in the Central Plain. The largest concentrations have been recorded near Solon Springs, Douglas County; 192 were recorded on 23 December 1974.

Habitat: Common ravens are not characteristic of any one habitat during the breeding season. The Burnett County nest was found in an oak savannah that was invaded by jack pine. The Polk County nest was in mixed aspen-maple forest. Observations of apparent territorial common ravens indicate an attraction to Northern Hardwood Forest during the nesting season. Large numbers of common ravens are usually associated with garbage dumps during the winter.

Common Crow (*Corvus brachyrhynchos*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Spring migration begins in the Western Upland during mid-February with dispersal from local winter roosts. Numbers of migrants gradually increase, reaching peak numbers 25 March to 10 April. Fall migratio begins in late August with flock formation. Peak movements occur 20 September to 15 October and nonwintering birds have departed by 15 November.

Nesting Season Distribution: Common nesting bird in all regions. Breedin Bird Survey data indicate a fairly uniform breeding population throughou the Valley; greatest abundance is in the Central Plain (Table 5). Documente breeding records exist for all eight counties.

Winter: The CBC data (Table 4) show the winter distribution pattern of th common crow. This species is common to locally abundant in the Wester Upland, fairly common in the Central Plain, and rare and local in the Northern Highland. The highest winter counts include 959 (1 January 1975), 94 (1 January 1977), and 908 (1 January 1974), all on the Afton CBC.

Habitat: The common crow is primarily an edge species using several woodland habitat types. Common crow breeding habitat is further characterize by the association of agricultural fields or Old Field Community. Also use is Lowland Deciduous Forest and Northern Hardwood Forest. The occurrence of large farming operations and the resultant abundance of wast grains probably enhance the habitats of the Western Upland for winterin common crows.

FAMILY PARIDAE: Titmice

Black-capped Chickadee (*Parus atricapillus*)

Status: Regular permanent resident.

Distribution: Uncommon (locally common) nesting species in the Wester Upland, common and more widespread in the Central Plain and Norther Highland. Analysis of BBS data (Table 5) suggests a rapid increase in abundance moving northward from the southern oak forest type of the Wester Upland to the mixed deciduous–coniferous forest of the Northern Highland Goddard (1972) reported a breeding density of 15.1 pairs per 40 ha in mixe habitats along the Kinnickinnic River, Pierce County. Jackson (1943) reported that this species was "only moderately common at most localities" i northwestern Wisconsin. However, he reported it "seemed to be more plent ful . . . at Solon Springs."

Winter: Common and well-distributed winter resident in the Western Upland and Central Plain, uncommon in the Northern Highland. Christma Bird Count data (Table 4) also suggest that the largest winter densitie occur in the southern regions. Mean numbers of black-capped chickadees o the Afton CBC (Western Upland) are nearly three times as large as thos on the Solon Springs CBC (Northern Highland). Comparison of CBC and BBS data (Tables 4 and 5) shows that the relative abundance of this species among physiographic regions is reversed between seasons. This is logical considering the periodic influxes of this species into areas south of the breeding range throughout the eastern United States.

Habitat: The black-capped chickadee is rather cosmopolitan in its choice of habitats during the nesting season. Breeding pairs in the Western Upland use Southern Deciduous Forest and Lowland Deciduous Forest most extensively. Habitat use in the Central Plain includes Northern Hardwood Forest, Lowland Deciduous Forest, Black Spruce–Tamarack Bog, and Jack Pine Barren. In the Northern Highland, extensive use is made of Northern Hardwood Forest, primarily stands of medium-aged mixed forest that is dominated by sugar maple, basswood, and scattered white pine. Also important in this region are Lowland Coniferous Forest, Black Spruce–Tamarack Bog, and remnant stands of Upland Coniferous Forest. One important aspect of black-capped chickadee breeding habitat is the presence of natural cavities or dead snags for nest placement. The spread of Dutch Elm disease, primarily in Lowland Deciduous Forest, may benefit this species. Several breeding pairs that I observed in this habitat in the Western Upland were using holes in dead American elm that had been excavated by woodpeckers.

Boreal Chickadee (*Parus hudsonicus*)

Status: Casual winter resident, one summer record.

Winter: Boreal chickadees have been recorded on several CBC's: Afton—29 December 1966 and 1 January 1972; Suburban St. Paul—1 January 1975; Grantsburg—26 December 1976; and Solon Springs—23 December 1976. A single bird was recorded at St. Croix Falls (Polk County) on 3 January 1950, and one individual in Washington County on 30 September 1972.

Nesting Season Distribution: An adult was seen and heard near Solon Springs, Douglas County, on 27 June 1972. Boreal chickadees are not known to nest in northwestern Wisconsin; Bernard (1967) mentioned only winter records from Douglas County. Green and Janssen (1975) showed that the breeding range of this species in Minnesota extended south to central Carlton County.

The midsummer Douglas County record increases the probability that the boreal chickadee nests rarely in the Valley. An abundance of suitable Lowland Coniferous Forest habitat exists along the St. Croix in southern Douglas County and throughout Pine County. Additional field work in this region during the summer may provide confirmation of nesting.

Habitat: Boreal chickadees observed during the winter are usually found at feeding stations. The June 1972 observation was of a single bird in Lowland Coniferous Forest.

Tufted Titmouse (*Parus bicolor*)

Status: Regular permanent resident.

Distribution: Rare and local breeding species restricted primarily to the Western Upland. Establishment of this species in the lower Valley has been very recent. Roberts (1932) rarely found this bird in southeastern Minnesota and then primarily only during the winter months. Currently, the major area of abundance appears to be along the St. Croix River and its major tributaries north to Marine-on-St. Croix (Washington County). Confirmed nest records have been obtained from St. Croix and Washington counties. Edgar (1943) observed tufted titmice feeding their young in Washington County on 25 July 1943, thus providing the first confirmed nest record for Minnesota Occasional records from central Polk and southern Burnett counties (Bauers 1964), suggest another range extension. Young (1967) summarized the distribution of this species in Wisconsin and reported that the tufted titmouse was concentrated south of the Tension Zone in that State.

Habitat: Primarily a species of mature Lowland Deciduous Forest associated with major tributaries of the St. Croix River. Near Afton State Park (Washington County) and along the Kinnickinnic River (Pierce County) tufted titmice also use stands of medium-aged Southern Deciduous Forest.

FAMILY SITTIDAE: Nuthatches

White-breasted Nuthatch (*Sitta carolinensis*)

Status: Regular permanent resident.

Distribution: Fairly common permanent resident throughout the Valley, decreasing in abundance northward. Breeding Bird Survey data (Table 5) suggest that breeding white-breasted nuthatches occur in largest numbers i the Central Plain, becoming much less numerous in the heavily foreste Northern Highland. Bernard (1967), however, considered this specie common in Douglas County. Goddard (1972) reported a breeding seaso density of 14.7 pairs per 40 ha along the Kinnickinnic River, Pierce County.

Winter: Common winter resident in the Western Upland, fairly common i the Central Plain, and uncommon in the Northern Highland. Christmas Bir Count data (Table 4) show a rapid decrease in relative abundance movin northward through the Valley. Densities in birds per party hour are nearl 10 times greater on the Afton Count (Western Upland) than on the Solo Springs Count (Northern Highland).

Habitat: Primarily a species of various deciduous forest communities including Southern Deciduous Forest, Lowland Deciduous Forest, and Northern Hardwood Forest. Rarely encountered during the breeding season i pure coniferous forest. Although nests are frequently placed in coniferou trees (primarily white pine), breeding pairs are usually associated wit extensive mixed deciduous–coniferous forest. Breeding pairs regularly us large deciduous trees in residential areas. Residential feeding stations ar important during winter.

Red-breasted Nuthatch (*Sitta canadensis*)

Status: Regular migrant, nesting species, and winter resident.

Migration: An irruptive species, usually an uncommon migrant throughout the Valley. During years of peak migration, red-breasted nuthatches are common to locally abundant, primarily in the Northern Highland and Central Plain. In years when this species stages a major population influx, the first migrants may arrive by 15 July and build gradually to a 20 September to 15 October peak. Fall migrants arrive in the Central Plain and Western Upland during late August (earliest—19 August 1970, Washington County). Peak fall abundance occurs 1 October to 15 November. Peak spring migration occurs 15 March to 15 April and most have departed nonbreeding areas by 15 May.

Nesting Season Distribution: Green and Janssen (1975) reported that nests or family groups were observed in Washington County. These authors showed that the breeding range of the red-breasted nuthatch included all three Minnesota counties. There are no known breeding records for the Wisconsin counties. Nesting season adults are rare in the Central Plain and uncommon in the Northern Highland. Breeding Bird Survey data (Table 5) suggest that this nuthatch is uncommon in southern Douglas County and throughout Pine County.

Winter: Uncommon to rare and irregular winter resident in the Western Upland, uncommon in the Central Plain, and fairly common in the Northern Highland (Table 4). The occasional winter irruptions are considered to be reated to the failure of the pinecone crop in northern nesting regions. Young's 1965) analysis of winter red-breasted nuthatch distribution in Wisconsin suggests that largest densities occur north of the Tension Zone.

Habitat: During the nesting season, the red-breasted nuthatch is characterstic of Lowland Coniferous Forest that supports black spruce, tamarack, and yellow birch in the overstory. Occasional breeding pairs are also recorded in Black Spruce–Tamarack Bogs, and in Northern Hardwood Forest that exhibits a mixture of coniferous and deciduous tree species. Winter habitat use is similar to that of the nesting season in the Northern Highland and Central Plain. Wintering red-breasted nuthatches in the Western Upland make extensive use of Pine Plantations. Ornamental conifers associated with feeding stations in residential areas also receive use during the winter.

FAMILY CERTHIIDAE: Creepers

Brown Creeper (*Certhia familiaris*)

Status: Regular migrant, winter resident, and probable nesting species.

Migration: Fairly common migrant throughout the Valley. Spring migrants arrive in the Western Upland 10–20 March, reaching the Northern Highland about 25 March. Peak spring abundance occurs 10–20 April and departure by 10 May (latest—19 May 1966, Washington County). The first fall migrants arrive in the Western Upland 1–10 September. Peak fall abundance occurs 25 September to 25 October and most have departed by 20 November.

Nesting Season Distribution: Uncommon and local resident, restricted primarily to the Northern Highland, although occasionally observed in the Central Plain. There is no direct evidence of nesting in the Valley. I have observed breeding season adults along the upper St. Croix River in Douglas and Pine counties in 1976 and 1977. Although I observed no nests or young, these records suggest possible nesting. Intensive field work in southern Douglas and throughout Pine counties during late May and June may shed additional light on brown creeper breeding status.

Winter: Brown creepers occur throughout the Valley during early winter; observations were made until 23 December in southern Douglas County. During midwinter this species is rare or absent in the Northern Highland and Central Plain, uncommon and local in the Western Upland.

Habitat: My observations of brown creepers during the nesting season have been confined to extensive stands of Northern Hardwood Forest that are dominated by mixed sugar maple, basswood, white birch, trembling aspen, red pine, and white pine. During the winter Lowland Deciduous Forest, dominated by silver maple, American elm, and green ash, is used extensively. Occasional use is also made of mixed-oak forest and Pine Plantations.

FAMILY TROGLODYTIDAE: Wrens

House Wren (*Troglodytes aedon*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants arrive in the Western Upland 20–25 April (earliest—15 April 1978, St. Croix County) and reach the Northern Highland about 25 April. Peak spring migration occurs 1–10 May. Peak fall migration occurs 25 August to 15 September and departure by 10 October.

Nesting Season Distribution: Breeding Bird Survey data (Table 5) show that this is the most numerous wren in the Valley during the nesting season and that relative abundance is similar throughout the Valley. Jackson (1943) observed that the house wren was a common nesting species throughout northwestern Wisconsin. Goddard (1972) found that house wrens were the third most abundant breeding species in the Kinnickinnic River Valley, Pierce County. Mean density in that area was 36.1 pairs per 40 ha.

Habitat: A characteristic species of several deciduous forest communities including Southern Deciduous Forest, Old Field Community, Northern Hardwood Forest, Lowland Deciduous Forest, and Deciduous Clear Cut. Also important are edge habitats including forest-agricultural field borders, brushy road ditches, and brushy fencerows. Jackson (1943) found house wrens "especially abundant" in burns and cut-over land. This species has adapted well to ornamental plantings in residential areas and is a familiar "back yard" bird, responding especially well to artificial cavities.

Winter Wren (*Troglodytes troglodytes*)

Status: Regular migrant and nesting species, two winter records.

Migration: Uncommon migrant throughout the Valley. Spring migrants arrive in the Western Upland 30 March to 10 April, reaching the Northern Highland 10–15 April (earliest—27 March 1942, Burnett County; Feeney 1942). Peak spring migration through the Valley occurs 15 April to 1 May and departure from non-nesting areas occurs by 10 May. Fall migration begins in late August and the first migrants arrive in the Western Upland 10–15 September. Peak fall abundance occurs 25 September to 15 October and departure by 1 November.

Nesting Season Distribution: Uncommon nesting species restricted primarily to the Northern Highland (Table 5). Hofslund (1952) reported a nest with four young at Solon Springs, Douglas County. Rare and casual elsewhere during the nesting season. Green and Janssen (1975) mentioned summer records but no broods from Washington County. Several recent records suggest that the winter wren is probably established as a nesting species in northeastern Chisago County. Longley (1973*b*) reported winter wrens along Lawrence Creek, Chisago County, on 9 June 1973, and Bratlie (1976) observed a winter wren nest at the same location on 16 June 1976.

Winter: There are two records (1 January 1968 and 1973) from the St. Croix County portion of the Afton CBC.

Habitat: The winter wren is a characteristic nesting species of Lowland Coniferous Forest dominated by black spruce, balsam fir, and yellow birch. The Chisago County nesting area was described by Longley (1973*b*) as a hardwood forest consisting of sugar maple, yellow birch, American elm, ash, white pine, and red pine.

Bewick's Wren (*Thryomanes bewickii*)

Status: Casual migrant and summer resident.

Records: S. D. Robbins observed Bewick's wrens near North Hudson, St. Croix County, on four occasions: 5–17 May 1963; 13 May 1964; 7 May 1965; nd 17 June 1961. Green and Janssen (1975) mentioned that Bewick's wren had been observed during the summer in Washington County.

Carolina Wren (*Thyrothorus ludovicianus*)

Status: Casual migrant, nesting species, and winter visitor.

Migration Records: Roberts (1938) reported the observation of a single Caroina wren at Woodbury, Washington County, on 30 May 1935. One was oberved at St. Croix Falls, Polk County (no date), during 1940 (Kumlien and

Hollister 1951). I found one along the Kinnickinnic River, Pierce County, or 26 April 1977. S. D. Robbins found one near Roberts, St. Croix County, or 3 May 1965 (Faanes and Goddard 1976). Olyphant (1972) caught and bandec a Carolina wren in Washington County on 26 October 1971. This birc remained in the area through at least 4 January 1972.

Winter: One Carolina wren was reported on the Afton CBC in Washingtor County on 1 January 1974 (Eckert 1974). W. Gantenbein observed singl Carolina wrens at Osceola, Polk County, during December 1965 tc 13 January 1966 (Hilsenhoff 1966), and December 1966 to 14 January 1967.

Nesting Season Distribution: Green and Janssen (1975) reported that Carolina wrens have nested in Washington County. In 1938, two Carolina wren were observed at St. Croix Falls by S. Owen from 15 April to 4 September During the summer of 1938, several unsuccessful nest searches were made but on 2 and 3 July the adults were seen with four fully grown young.

Habitat: Primarily a species of Lowland Deciduous Forest and adjacen edge habitats.

Long-billed Marsh Wren (*Cistothorus palustris*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant in the Western Upland and Centra Plain, uncommon to rare and local in the Northern Highland. Sprin migrants arrive in the Western Upland 25–30 April and the Northern Highland 1–5 May. Peak abundance during spring migration occurs 10–20 May Fall migration begins in late August. Peak abundance in the Western Upland occurs 5–15 September and departure by 15 October.

Nesting Season Distribution: Uncommon and local nesting species in th Western Upland and Central Plain, rare and local in the Northern Highland Evidence of nesting has been obtained in Burnett, Chisago, Polk, St. Croix and Washington counties.

Habitat: A characteristic nesting species of seasonally, semipermanently and permanently flooded wetlands. Principal vegetation associated wit long-billed marsh wren nesting habitat includes cattail, hardstem bulrush river bulrush, burreed, and phragmites. This species nests in reduce numbers along the edges of more acidic northern Forest Bordered Wetland and in emergent vegetation along rivers.

Short-billed Marsh Wren (*Cistothorus platensis*)

Status: Regular migrant and nesting species.

Migration: Common migrant in the Western Upland and Central Plain, uncommon and local in the Northern Highland. Spring migrants arrive in th Western Upland 25–30 April and the Northern Highland 1–5 May. Pea spring migration through the Valley occurs 15 May to 5 June. Fall migration begins during early August with a gradual exodus from nesting area

Peak fall migration occurs 25 August to 10 September and departure by 1 October.

Nesting Season Distribution: Common to abundant nesting species in the Western Upland and Central Plain, uncommon and local in the Northern Highland. Breeding Bird Survey data (Table 5) suggest that the greatest abundance occurs in the Central Plain.

Habitat: In the Central Plain and Northern Highland, the species is found in Northern Sedge Meadow dominated by tussock sedge, manna grass, and bluejoint grass. In the Western Upland, breeding pairs are frequently encountered in Shrub Carr Wetlands. During dry years, this wren also uses alfalfa and timothy hayfields, Managed Grasslands, and occasionally Old Field Community.

FAMILY MIMIDAE: Mockingbirds and Thrashers

Mockingbird (*Mimus polyglottos*)

Status: Casual visitor.

Records: The first record was obtained at Crex Meadows, Burnett County, on 7 May 1958 (MacBriar 1958). One was recorded at Crex Meadows on 5 and 16 May 1964 (Soulen 1965). Two were recorded in Washington County on 23 May 1978 (Willard 1971) and 19 July 1978 (Green 1979). Single mockingbirds were observed at Crex Meadows on 10 May 1975 and 23 May 1976 M. Link, personal communication), and on 18 May 1980 (D. D. Tessen, personal communication). Faanes and Goddard (1976) cited a 25 April 1976 ecord from near Woodville, St. Croix County.

Gray Catbird (*Dumetella carolinensis*)

Status: Regular migrant and nesting species, casual in winter.

Migration: Common (locally abundant) migrant throughout the Valley. Spring migrants arrive in the Western Upland 1–5 May and the Northern Highland 5–10 May. Peak spring abundance occurs 10–20 May. Fall migration begins in mid-August. Peak fall migration occurs 5–20 September and departure 5–10 October.

Nesting Season Distribution: Fairly common (locally common) nesting pecies in the Western Upland, common in the Central Plain and fairly ommon in the Northern Highland. Goddard (1972) found the gray catbird he most abundant nesting species in the Kinnickinnic River Valley, Pierce County. Breeding density in that area was 48.9 pairs per 40 ha. Breeding Bird Survey data (Table 5) show that this species is well distributed throughout the Valley and that greatest densities occur in the Central Plain.

Winter: Polk County records include 9 January to 30 March 1956 at Luck Lound and Lound 1957*a*), and December 1956 to 19 January 1957 (Lound nd Lound 1957*b*). A single gray catbird remained at a Newport feeder

(Washington County) until 27 December 1964 (Huber 1965). One observed at St. Croix Falls, Polk County, on 9 March 1948 may have wintered locally (Robbins 1948*c*).

Habitat: Primarily a species of deciduous forest edge habitats. Important among these are second-growth Northern Hardwood Forest, Deciduous Clear Cuts, Old Field Community, and fencerows. Lowland Deciduous Forest is occasionally used in the Western Upland and Black Spruce–Tamarack Bogs receive limited use in the Northern Highland. In residential areas, ornamental shrubbery is used.

Brown Thrasher (*Toxostoma rufum*)

Status: Regular migrant and nesting species, casual early winter resident.

Migration: Common migrant in the Western Upland and Central Plain, fairly common in the Northern Highland. Spring migrants arrive in the Western Upland 20–25 April (earliest—4 April 1975, Washington County) and reach the Northern Highland 25–30 April. Peak spring abundance occurs 1–15 May. Fall migration begins 15–30 August; peak movements occur 5–20 September and departure by 10 October.

Nesting Season Distribution: Common nesting species in the Western Upland and Central Plain, fairly common and more local in the Northern Highland. Jackson (1943) reported this species as "not common" in northwestern Wisconsin in 1919 but almost 50 years later, Bernard (1967) considered brown thrashers "common" in Douglas County. Breeding Bird Survey data (Table 5) suggest a gradual decrease in relative abundance moving northward across the Valley. Major changes in abundance appear to occur between the Central Plain and Northern Highland. Goddard (1972) reported a breeding density of 6.4 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Winter: There are three early winter records from Washington County: 20 December 1969, 29 December 1973, and 1 January 1975. One remained at a Pierce County feeder through 11 January 1976 (Faanes and Goddard 1976).

Habitat: Primarily a species of edge habitats. Important among these are natural clearings in Southern Deciduous Forest, Old Field Community, brushy fencerows, and Deciduous Clear Cuts. Recently logged oak forests and grazed woodlots supporting an abundance of prickly ash and hawthorn are frequently used in the Western Upland.

FAMILY TURDIDAE: Thrushes, Solitaires, and Bluebirds

American Robin (*Turdus migratorius*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Abundant migrant throughout the Valley. The first spring migrants arrive in the Western Upland during the first 10 days of March, reaching the Northern Highland 15–25 March. Peak spring migration through the Valley occurs 25 March to 15 April. Fall migration begins during late August with the formation of loose feeding flocks. Peak fall migration occurs 15 September to 10 October and most have departed by 1 November. During the peak of fall migration, flocks of 50 to 75 individuals are regularly encountered and occasional groups of 200 to 250 have been recorded.

Nesting Season Distribution: Abundant nesting species in the Western Upland and Central Plain, common in the Northern Highland. Jackson (1943) considered the American robin abundant throughout northwestern Wisconsin in 1919. Breeding Bird Survey data (Table 5) show that the American robin is by far the most numerous nesting thrush in the Valley. Goddard (1972) recorded a nesting density of 18.4 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Winter: This species is fairly well distributed throughout the Valley; several midwinter records exist from Burnett, Douglas, and Pine counties. American robins are regularly observed during midwinter in the Western Upland and appear to be dependent on trees and shrubs (mountain ash, cedar) that retain their fruits throughout the period.

Habitat: Breeding American robins are found in nearly all habitat types in the Valley. This species has adapted well to man's continued alteration of the Valley and is a common breeding species in park-like Residential Habitats. The establishment of Pine Plantations, particularly in the Western Upland and Central Plain, has provided increased areas of excellent nesting habitat.

Varied Thrush (*Ixoreus naevius*)

Status: Casual winter visitor.

Records: This western thrush has been recorded in the Valley at least seven times. Minnesota records include one at Stillwater, Washington County, from mid-December to 30 March 1974 (Eckert 1974). Additional Washington County records include single birds on 3 January 1976, late November 1976, and 9 January 1977. Longley (1967) observed a single bird in Chisago County on 13 November 1966. Records from the Wisconsin counties include one bird at Osceola, Polk County, from early December 1948 until 21 April 1949 (Simmons 1949). One apparently wintering bird remained near Grantsburg, Burnett County, from 12 November 1963 to mid-March 1964 (Bauers 1964).

Habitat: Varied thrushes in this region are usually found at feeding stations. Surrounding habitats include Southern Deciduous Forest composed primarily of Hill's and white oak and brushy edges.

Wood Thrush (*Hylocichla mustelina*)

Status: Regular migrant and nesting species.

Migration: Uncommon migrant throughout the Valley. Spring migrants arrive in the Western Upland 1–5 May, reaching the Northern Highland 10–15 May. Peak spring migration through the Valley occurs 10–25 May. During late July this species becomes very secretive and is not regularly encountered. Peak fall migration apparently occurs 15–30 August and departure 20–30 September.

Nesting Season Distribution: Uncommon nesting species throughout the Valley. Jackson (1943) found this species "fairly common" at St. Croix Falls and heard it occasionally at Danbury (Burnett County) in 1919. Breeding Bird Survey data (Table 5) show a fairly uniform breeding density throughout the Western Upland and Central Plain. The greatest abundance apparently occurs in the Northern Highland. In Minnesota, however, Green and Janssen (1975) consider it most common south of the latitude occupied by the Twin Cities. Goddard (1972) reported a density of 2.1 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Habitat: In the Western Upland, the wood thrush is most common in mature Southern Deciduous Forest and Lowland Deciduous Forest. Breeding pairs in the Central Plain are most commonly encountered in mesic Northern Hardwood Forest. In the Northern Highland, this species uses Northern Hardwood Forest and is occasionally found in Lowland Coniferous Forest. In all instances, wood thrushes appear to select woodlands with a closed canopy of mature trees.

Hermit Thrush (*Catharus guttatus*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. The hermit thrush is the first of the *Catharus* thrushes to arrive in spring. The first migrants arrive in the Western Upland 5–10 April (earliest—31 March 1967, Washington County) and reach the Northern Highland 10–15 April. Peak spring migration occurs 15–25 April and departure from nonbreeding areas occurs by 10 May. Fall migration begins in late August. Peak abundance occurs 25 September to 15 October and departure by 1 November (latest—5 November 1975).

Nesting Season Distribution: Fairly common nesting species in the Northern Highland, rare and local in the Central Plain (Table 5). Confirmed nest records exist for Douglas and Pine counties, and nesting is inferred in Burnett and Polk counties.

Habitat: This species is characteristic of wet coniferous–deciduous forests in the Northern Highland. Important among these are Lowland Coniferous Forest, Black Spruce–Tamarack Bogs, and low areas of Northern Hardwood Forest. Breeding pairs also use drier portions of Jack Pine Barrens throughout the Northern Highland.

Swainson's Thrush (*Catharus ustulatus*)

Status: Regular migrant and probable nesting species.

Migration: Common spring and abundant fall migrant throughout the Valley. Spring migrants arrive in the Western Upland 5–10 May (earliest—30 April 1950, Polk County), reaching the Northern Highland 10–15 May. Peak abundance through the Valley occurs 15–25 May and departure by 5 June (latest—8 June 1968, Polk County). This species is the first of the *Catharus* thrushes to arrive in the fall. The first migrants arrive in the Western Upland 5–10 August (earliest—27 July 1966, St. Croix County). Peak abundance through the Valley occurs 25 August to 15 September and departure by 10 October.

Nesting Season Distribution: Rare and local in the Northern Highland during the nesting season. There are no confirmed records of nesting in the Valley. Green and Janssen (1975) showed the probable breeding range of this thrush to include northern and central Pine County. Roberts (1932) mentioned records that suggest nesting in Pine County in 1918. I recorded one singing male along the St. Croix River in Douglas County on 20 June 1976. This is my only summer record for the Valley.

Habitat: During migration, Swainson's thrush regularly uses a wide range of deciduous and coniferous communities. My only nesting season record was obtained from a large tract of Lowland Coniferous Forest that was dominated by black spruce, balsam fir, and yellow birch.

Gray-cheeked Thrush (*Catharus minimus*)

Status: Regular migrant.

Migration: Uncommon migrant throughout the Valley. Spring migrants arrive in the Western Upland 5–10 May (earliest—1 May 1967, St. Croix County), reaching the Northern Highland about 10 May. Peak migration occurs 15–25 May and departure by 5 June. Fall migrants arrive in the Northern Highland in mid-August, reaching the Western Upland 25–30 August. Peak fall migration occurs 5–15 September and departure by 1 October.

Habitat: Largely restricted to mature tracts of Upland and Lowland Deciduous Forest in the Western Upland. In the Central Plain and Northern Highland, this species is most numerous in Northern Hardwood and Lowland Coniferous Forests.

Veery (*Catharus fuscescens*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants arrive in the Western Upland 25 April to 1 May, reaching the Northern Highland 1–5 May. Peak spring migration through the Valley occurs 10–25 May. Fall migration begins in early August. Peak abundance occurs 20 August to 10 September and departure by 1 October.

Nesting Season Distribution: Common nesting species in the Northern Highland and Central Plain, uncommon to rare and local in the Western

Upland. Jackson (1943) reported that the veery was common throughout northwestern Wisconsin. The southern limit of the breeding range is closely associated with the southern limit of maple–basswood forest. This range limit occurs about at the latitude occupied by Marine-on-St. Croix, Washington County. Breeding Bird Survey data (Table 5) suggest a rapid increase in relative abundance moving northward across the Valley.

Habitat: Primarily a species occupying various age classes of moist deciduous forest. In the Northern Highland and Central Plain, this species uses mature stands of Northern Hardwood Forest dominated by sugar maple, basswood, trembling aspen, and white birch. Alder Thicket, Lowland Coniferous Forest, and Black Spruce–Tamarack Bogs are also used in these regions. In the Western Upland, habitat use is almost entirely restricted to mixed maple–oak Forest. Occasional use is made of Shrub Carr wetlands that support an abundant growth of silver willow.

Eastern Bluebird (*Sialia sialis*)

Status: Regular migrant and nesting species, casual in winter.

Migration: Fairly common spring and fall migrant in the Western Upland and Central Plain, more localized in the Northern Highland. Spring migrants arrive in the Western Upland 20–30 March (earliest—12 March 1966, Washington County and 12 March 1977, Pierce County) and the Northern Highland about 1 April. Peak abundance through the Valley occurs 15–30 April. Fall migration begins with the formation of loose family groups in mid-August. Peak fall abundance occurs 15 September to 10 October and departure by 1 November (latest—30 November 1967, Washington County). On 17 October 1964, W. E. Scott observed an estimated 200 eastern bluebirds near St. Croix Falls, Polk County (Kemper 1965).

Nesting Season Distribution: Fairly common nesting species throughout the Valley. Jackson (1943) found this species common in northwestern Wisconsin, especially in recently burned areas. Breeding Bird Survey data (Table 5) suggest that a fairly uniform abundance exists throughout the Western Upland and Central Plain, except in the Jack Pine Barren region along the Union transect, Burnett County.

Concern has been expressed about the status of the eastern bluebird in North America (cf. Arbib 1978) and in Wisconsin (R. L. Hine, personal communication). Some authorities believe that population declines are related to mortality on the wintering grounds, whereas others believe these declines are related to competition for nest sites with other hole-nesting species (e.g., house sparrow). Careful monitoring of the Valley population should be undertaken to determine if declines are occurring.

Winter: One bird was observed at St. Croix Falls, Polk County, on 7 and 8 February 1948. Two birds were observed in Washington County on 20 December 1969. Roberts (1932) mentioned, without details, winter records from Washington County.

Habitat: The eastern bluebird is a characteristic species of edge and open habitats including fencerows, early successional stage deciduous forest, Deciduous Clear Cuts, and openings in grazed woodlots. In the Northern Highland and Central Plain, extensive use is made of Jack Pine Barrens. This is evidenced by the high relative abundance of this species along the Union BBS transect, Burnett County. Local populations, particularly in agricultural areas, can be enhanced by the establishment and monitoring of bluebird houses. Many 4-H Clubs and Future Farmers of America (FFA) chapters have created "Bluebird Trails" that are very beneficial in providing nesting sites.

Townsend's Solitaire (*Myadestes townsendi*)

Status: Accidental.

Records: One Townsend's solitaire was observed at Hudson, St. Croix County, from December 1942 to 10 January 1943 (Scott 1943*a*). Longley (1973*a*) described the observation of a single bird in Chisago County on 27 April 1973.

FAMILY SYLVIIDAE: Gnatcatchers and Kinglets

Blue-gray Gnatcatcher (*Polioptila caerulea*)

Status: Regular migrant and nesting species.

Migration: Uncommon and local migrant restricted primarily to the Western Upland. Spring migrants arrive 1–5 May and are most conspicuous after 15 May. Fall migration apparently begins in late July with dispersal of family groups. This species is most common during the fall 1–15 August and departure occurs by 25 August (latest—6 September 1975, Washington County).

Nesting Season Distribution: Uncommon and local nesting species in the Western Upland. Occasional summer records at St. Croix Falls, Polk County, suggest possible nesting. The observations by Breckenridge (in Roberts 1932) and Maurer (1970) of nests at Marine-on-St. Croix are probably the northernmost documented records in the Valley. Breckenridge reported two adults, but no young, at Taylor's Falls, Chisago County, on 11 August 1938 (Erickson and Upson 1938). The area of greatest abundance is restricted to the lower St. Croix River and its major tributaries from Stillwater, Washington County, south to its confluence with the Mississippi River.

The status of this species as a nesting bird in the Valley is apparently changing. Robbins (1963) suggested that as of 1962 blue-gray gnatcatchers "may not be counted on to be present every year" at Hudson, St. Croix County. Since first observing nesting pairs along the Willow River at Hudson in 1973, the number of pairs on one site has risen from 7 in 1973 to 17 in 1978. Expansion of this species along major St. Croix River tributaries in Wisconsin is also evident. During 1976 and 1977, breeding pairs were located along the Kinnickinnic River near Roberts, St. Croix County (Sec. 11, T. 28 N., R. 18 W.), along the Willow River near Jewett, St. Croix County

(Sec. 4, T. 30 N., R. 17 W.), and along the Apple River near Amery, Polk County (Sec. 8, T. 32 N., R. 17 W.). Expansion along streams that are tributary to the St. Croix River in Washington County has also been observed.

Habitat: Characteristic species of mature tracts of Lowland Deciduous Forest along the St. Croix and its tributaries. Several breeding pairs located along the Lower Kinnickinnic River, Pierce County, in 1976 were using medium-aged Southern Deciduous Forest that was dominated by white oak and Hill's oak. The territories occupied by five pairs in 1976 and seven pairs in 1977 along the Willow River were associated with sapling cottonwood and green ash in the Lowland Forest. Three nests were placed from 2.1 to 6.1 m above the ground in young green ash trees.

Golden-crowned Kinglet (*Regulus satrapa*)

Status: Regular migrant and winter resident.

Migration: Fairly common migrant throughout the Valley. Spring migrants arrive in the Western Upland 15–25 March, reaching the Northern Highland 25–30 March. Peak abundance through the Valley occurs 5–25 April and departure by 15 May. Green and Janssen (1975) stated that the St. Croix River Valley can be included in this species' breeding range in Minnesota, although there are no breeding records to support this. Fall migrants arrive in the Northern Highland in mid-September, reaching the Western Upland 25 September to 1 October. Peak fall abundance occurs 15 October to 1 November and most have departed by 1 December.

Winter: Uncommon to rare and local winter resident in the Western Upland, casual in the Northern Highland where several late December records have been obtained.

Habitat: During migration and winter, this species is most commonly observed in coniferous communities and occasionally in Lowland Deciduous Forest. Most important among coniferous habitats are Pine Plantations and Lowland Coniferous Forest dominated by black spruce, balsam fir, and hemlock.

Ruby-crowned Kinglet (*Regulus calendula*)

Status: Regular migrant, casual summer and early winter resident.

Migration: Common spring and fall migrant throughout the Valley. Spring migrants arrive in the Western Upland 5–10 April, reaching the Northern Highland by 15 April. Peak abundance occurs 1–10 May and departure by 25 May. A female collected at St. Croix Falls, Polk County, on 22 May 1919, was considered a migrant (Jackson 1943). Fall migrants arrive in the Northern Highland 1–10 September, reaching the Western Upland about 10 September (earliest—23 August 1963, St. Croix County). Peak fall abundance occurs 25 September to 10 October and departure by 30 October.

Nesting Season Distribution: There are no documented nest records in the Valley. Green and Janssen (1975) showed that the breeding range of this species in Minnesota extended south to the northern border of Pine County. On 20 and 21 June 1976, I observed two singing male ruby-crowned kinglets along the St. Croix River in Douglas County (Sec. 24, T. 43 N., R. 14 W.). Although the behavior of these birds suggested nesting, I failed to observe nests or young.

Winter: Casual early winter resident in the Western Upland, usually observed during the CBC period. The latest observations are two birds on the Afton CBC 1 January 1976.

Habitat: During migration, this species uses a wide range of both deciduous and coniferous communities. During these periods, ruby-crowned kinglets appear to prefer brushy communities including Deciduous Clear Cuts. The singing males that I recorded in Douglas County were in an extensive Lowland Coniferous Forest dominated by black spruce, balsam fir, and yellow birch.

FAMILY MOTACILLIDAE: Pipits

Water Pipit (*Anthus spinoletta*)

Status: Regular migrant.

Migration: Uncommon migrant in the Western Upland and Central Plain, rare or absent in the Northern Highland. Spring migrants arrive in the Western Upland 25 April to 5 May. Peak spring abundance through the Valley occurs 10–20 May and departure by 25 May. Fall migrants arrive during mid-September. Peak fall abundance occurs 25 September to 10 October and departure by 25 October.

Habitat: Primary habitat includes seasonally flooded wetlands, agricultural fields, and man-made impoundments that are managed for waterfowl production. During fall migration, this species is especially numerous in recently plowed agricultural fields.

FAMILY BOMBYCILLIDAE: Waxwings

Bohemian Waxwing (*Bombycilla garrulus*)

Status: Casual migrant and winter resident.

Migration: This species is erratic in both distribution and abundance. The highest frequency of occurrence appears to be in the Western Upland. Although fall arrival periods are not regular, small flocks begin to arrive 20 November to 15 December. Spring departure is also irregular; most flocks leave by mid-March (latest—6 April 1970, Washington County).

Winter Distribution: An irregular winter resident throughout the Valley. Observations of Bohemian waxwings during midwinter usually consist of flocks of 15 to 30 birds. Most records have been obtained during the CBC period during the last 2 weeks of December.

Habitat: Most of my observations have involved birds foraging at the edge of deciduous forests or flocks in residential areas. The existence of vegetation that retains its fruit into the winter is important in maintaining this waxwing. Among these plants mountain ash and flowering crab apple, established as ornamentals in residential areas, are most important.

Cedar Waxwing (*Bombycilla cedrorum*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Common to abundant spring and fall migrant throughout the Valley. Determination of arrival dates is compounded by the irregular nature of waxwing movements. During years when winter populations are very low, the first noticeable influx of migrants occurs 1–20 May, reaching a peak 1–15 June. When summer populations are low, fall movements occur from mid-August through 30 November and peak abundance usually occurs during late September.

Nesting Season Distribution: Fairly common nesting species throughout the Valley. Jackson (1943) reported that cedar waxwings were common throughout most of northwestern Wisconsin during the 1919 nesting season Breeding Bird Survey data suggest that the largest population occurs in the Central Plain and Northern Highland. Goddard (1972) reported a density of 9.7 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Winter: Common to abundant winter resident in the Western Upland and Central Plain, uncommon in the Northern Highland. Yearly winter populations are characterized by large fluctuations, probably related to the abundance and availability of a food source. This species, like the Bohemian waxwing, is closely associated with fruit-bearing trees during the winter.

Habitat: Primarily a species of open or semi-open deciduous forest. Important among these habitats are openings in Southern Deciduous Forest, Northern Hardwood Forest, and Deciduous Clear Cuts. Nesting cedar waxwings also use, to a lesser extent, coniferous communities and ornamental shrubbery in residential areas.

FAMILY LANIIDAE: Shrikes

Northern Shrike (*Lanius excubitor*)

Status: Regular migrant and winter resident.

Migration: Uncommon to rare migrant throughout the Valley. The first fall migrants arrive in the Northern Highland 20–30 October, reaching the Western Upland 1–15 November (earliest—22 October 1976, St. Croix County). This species is most frequently encountered 20 November to 10 January. During spring migration, peak numbers occur 1–15 March and departure by 15 April (latest—26 April 1953, Burnett County).

nter: Rare winter resident throughout the Valley, most regularly obved in the Western Upland and Central Plain.

bitat: Primarily a species of semi-open natural habitats and agricultural ımunities during migration and winter. Most northern shrikes are obved perched near the edge of wooded habitats and open fields or along erows and highway rights-of-way. The northern shrike is observed infrently in coniferous habitat including Lowland Coniferous Forest and ck Spruce–Tamarack Bogs.

ggerhead Shrike (*Lanius ludovicianus*)

tus: Regular migrant and nesting species, accidental in winter.

ration: Formerly common throughout the Valley, this species is now rare ing migration. The spring migration period extends from early April (eart—27 March 1954, Burnett County) through early May. Fall migration ırs from late August through mid-October (latest—2 November 1972, nett County). Caution must be exercised when identifying shrikes during il and October, because their plumage is similar to the northern shrike.

ting Season Distribution: Formerly a fairly common breeding species; ding was documented as far north as Solon Springs in Douglas County. kson (1943) noted that "several birds were seen in the open pine barrens miles south of Solon Springs on 4 August 1919, where two families of grown young were located." Within the last 15 years, however, the us of the loggerhead shrike during the nesting season has changed. Erd(1970) summarized the status and distribution of this shrike in Wisin, concluding that it was experiencing a statewide decline. Erdman prod information on a nest site near Clayton, Polk County, that is now the hernmost location in the Valley. Loggerhead shrikes were observed in hern Pine County during the 1974 nesting season (Eckert 1974). How, no nests or young were found.

uring 1977, I located two nesting pairs that produced five young in St. x County. In 1978, five pairs were located in that county, primarily ben Roberts and New Richmond. I observed an additional pair during about 6.4 km south of Lake Elmo, Washington County.

ter: There are two records of the loggerhead shrike during winter ining one bird in Washington County on 1 January 1976. R. E. Faanes obed the other bird hunting near a bird feeder in Hudson, St. Croix nty, on 15 February 1978.

itat: Primarily a species of edge habitats including fencerows, thorny erows, and brush areas associated with grazed deciduous woodlots. ent clean farming practices, including fencerow removal, may be onsible for some of the decline observed in the breeding population.

FAMILY STURNIDAE: Starlings

Starling (*Sturnus vulgaris*)

Status: Introduced. Regular migrant, nesting species, and winter residen

Migration: Abundant migrant in the Western Upland and Central Plain, common in the Northern Highland. Dates of spring arrival are difficul determine because of wintering individuals. However, large increases in population occur from late February through 20 March. During fall mi tion, flocks begin forming in early August and peak movements oc 15 September to 15 October.

Nesting Season Distribution: Abundant nesting species in the West Upland and Central Plain; uncommon and local in the Northern Highla The first record of this species in the Valley was obtained from St. Cr County in 1937 (Anonymous 1939). Since that time, the starling populat has expanded and the species now breeds throughout the Valley. Breed Bird Survey data show that largest populations occur in areas hea settled by humans and where agriculture has expanded. The mean numbe starlings recorded along the route of the Dresser BBS (Polk County) is 4 however, in the heavily forested region traversed by the Union BBS ro (Burnett County), this species was not recorded.

Winter: Common to locally abundant winter resident in the West Upland, fairly common in the Central Plain, and uncommon to rare or abs in the Northern Highland. During this period, large flocks of starlings associated with cattle feedlots or barnyards in agricultural areas, and n feedmills and feeder operations in residential areas.

Habitat: Starlings nest in a variety of vegetation types, and in residen buildings, or in nest boxes erected for other species. Starlings have b considered an important factor in the decline of several more desira species including the red-headed woodpecker and eastern bluebird. Beca starlings return to their breeding areas and establish territories earlier t other hole-nesting species, they dominate these nest sites before ot migrants return.

FAMILY VIREONIDAE: Vireos

White-eyed Vireo (*Vireo griseus*)

Status: Accidental.

Record: An adult white-eyed vireo was trapped and banded at the War Nature Center, Washington County, on 3 May 1977 (Wojahn 1977).

Bell's Vireo (*Vireo bellii*)

Status: Casual migrant and summer resident.

ords: Five records exist during 13 May to 7 September: Polk County, lay 1974; Chisago County, 7 September 1968; and St. Croix County, lay 1964, 17 June to 21 July 1977, and 3 July 1963. The 1977 St. Croix nty record may have been a breeding pair. One male was observed ost daily on territory 5.6 km east of New Richmond. The male was heard ing and appeared to be defending a breeding territory. Attempts to te a nest or a mated female failed.

itat: The 1977 observation was of a bird in second-growth Lowland iduous Forest along the Willow River.

low-throated Vireo (*Vireo flavifrons*)

us: Regular migrant and nesting species.

ration: Uncommon migrant in the Western Upland and Central Plain, and local in the Northern Highland. Spring migrants arrive in the tern Upland 5–10 May and the Northern Highland 10–15 May and are distributed 15–25 May. Fall migration begins about 15 August. Peak ements occur 25 August to 10 September and departure 20–25 Sep- ber.

ing Season Distribution: Fairly common nesting species in the Western nd and Central Plain, uncommon and local in the Northern Highland. son (1943) recorded this species nesting at St. Croix Falls, Polk County; ever, he failed to obtain records elsewhere in northwestern Wisconsin. iard (1967) considered this vireo an "uncommon to rare summer resi- " in Douglas County. Nesting records have been obtained from Solon ngs, which is at the northern limit of their range in Wisconsin. There are ral nest records for Chisago and Pine counties, the farthest north at St. x State Park, Pine County (Sparkes 1953). Breeding Bird Survey data le 6) indicate that the breeding population is fairly uniform throughout Valley. Goddard reported a density of 2.9 pairs per 40 ha in the Kin- nnic River Valley, Pierce County.

itat: A characteristic breeding bird of mature deciduous forests. During reeding season, this species is most commonly found in Northern Hard- l Forest and Lowland Deciduous Forest. Occasional breeding pairs are ded in residential habitats and in Lowland Coniferous Forest.

tary Vireo (*Vireo solitarius*)

us: Regular migrant and nesting species.

ation: Uncommon to fairly common migrant throughout the Valley. ng migrants arrive in the Western Upland 1–5 May, reaching the North- ighland by 10 May. Peak spring migration occurs 10–20 May and de- ure from nonbreeding areas is by 30 May. Fall migration begins in the hern Highland in mid-August. The first migrants reach other regions 5 August. Peak fall migration occurs 10–20 September and departure) September (latest—27 October 1970, Pine County).

Table 6. *Mean number of vireos and warblers recorded on western W consin Breeding Bird Survey transects, 1966–78.*

	Western Upland	Central Plain		Northern Highlan	
Species	Hudson	Dresser	Loraine	Union	Mino
Vireos					
Yellow-throated	1.2	1.7	2.8	3.8	2.0
Solitary	0.0	0.0	0.2	0.0	1.2
Red-eyed	3.6	6.6	21.3	16.1	41.2
Warbling	6.1	13.1	10.7	3.8	5.4
Warblers					
Black-and-white	0.0	<0.1	1.3	<0.1	6.9
Blue-winged	<0.1	0.0	0.0	0.0	0.0
Golden-winged	0.0	0.3	5.1	0.0	2.5
Nashville	0.0	<0.1	1.4	1.7	20.2
Yellow	2.5	5.8	21.9	1.6	8.0
Magnolia	0.0	0.0	0.0	0.0	<0.1
Cape May	0.0	0.0	0.0	0.0	<0.1
Yellow-rumped	0.0	0.0	0.0	0.2	1.9
Black-throated green	0.0	0.0	0.0	0.0	0.6
Blackburnian	0.0	0.0	0.0	<0.1	0.2
Chestnut-sided	0.3	0.2	5.2	3.9	29.8
Pine	0.0	0.0	0.3	0.4	3.8
Ovenbird	0.0	0.5	4.7	23.7	19.0
Common yellowthroat	7.9	12.6	36.2	14.6	36.2
Mourning	0.0	<0.1	1.2	<0.1	6.3
Connecticut	0.0	0.0	0.0	1.7	2.7
Canada	0.0	0.0	<0.1	0.0	1.7
American redstart	0.0	0.6	5.2	0.3	7.9

Nesting Season Distribution: Documented evidence of nesting by this exists only for Douglas County, where I observed an adult incubatin 11 June 1977. This bird was found along the St. Croix River about 6. west of Gordon, Wisconsin. Although there is considerable evidenc nesting in Burnett and Pine counties, neither nests or young have bee served. Breeding Bird Survey data (Table 6) also suggest that nesting i marily restricted to the Northern Highland.

Habitat: Solitary vireos are characteristic of Lowland Coniferous Fo Vegetation associated with the Douglas County nest site was Low Coniferous Forest dominated by black spruce and white cedar adjace the St. Croix River. Additional observations within the breeding range c in similar habitat or in Black Spruce–Tamarack Bogs.

Red-eyed Vireo (*Vireo olivaceus*)

Status: Regular migrant and nesting species.

ration: Common (locally abundant) migrant throughout the Valley. ing migrants arrive in the Western Upland 10-15 May, reaching the thern Highland by 20 May. The peak of migration occurs 20 May to ne. Fall migration begins 20-25 August. Peak abundance occurs 5 September and departure by 5 October.

ting Season Distribution: Fairly common nesting species in the Western and, common to locally abundant in the Central Plain and Northern land. Goddard (1972) reported this vireo to be among the 10 most abun- breeding birds in the Kinnickinnic River Valley, Pierce County. Mean ity in that area was 25.3 pairs per 40 ha. Analysis of BBS data (Table 6) ates a gradation in abundance moving northward through the Valley. mented nesting records exist for Polk, St. Croix, and Washington coun- and there is evidence of nesting in the other counties.

itat: Red-eyed vireos are largely restricted to various deciduous forest s during migration and the nesting season. Although not characteristic ny one habitat type, their abundance is predictable when compared ng geomorphic regions.

the Western Upland, highest breeding densities occur in mature Low- Deciduous Forest and mature Southern Deciduous Forest. In the Cen- Plain, breeding populations are greatest in mature Northern Hardwood st dominated by sugar maple and basswood. In the Northern Highland, lations are greatest in aspen forest and mature Northern Hardwood st.

adelphia Vireo (*Vireo philadelphicus*)

s: Regular migrant.

ation: Uncommon to rare migrant throughout the Valley. This is the t arriving vireo; average first appearance is 15 May in the Western nd. Migrants arrive in the Northern Highland about 20 May. Observa- usually are of single birds or occasionally pairs; therefore, peak migra- cannot be determined. Spring departure from the southern regions s by 30 May and from the Northern Highland by 5 June. Fall migrants 10-15 September. This species is most frequently encountered September and departs from 30 September to 5 October (latest— tober 1970, Washington County).

tat: Philadelphia vireos use a variety of habitat types during migration; ver, they are most regularly observed in medium-aged to mature ern Hardwood Forest.

bling Vireo (*Vireo gilvus*)

s: Regular migrant and nesting species.

tion: Common migrant in the Western Upland; fairly common in the al Plain and Northern Highland. Fairly common fall migrant in the ern Upland, uncommon to rare elsewhere. The mean date of spring arri-

val in the Western Upland is 8 May (earliest—1 May 1976, St. Croix Cou
and migrants reach the Northern Highland 10–15 May. Peak migra
through the Valley occurs 15–25 May. Fall migration begins 10–15 Aug
Peak fall migration occurs 20 August to 5 September and departur
20 September. Peak fall migration in the Western Upland occurs 10–20
tember and departure by 1 October.

Nesting Season Distribution: Fairly common to locally common nes
species in the Western Upland and Central Plain, rare to locally uncom
in the Northern Highland. Jackson (1943) considered this vireo to be
common when compared with the red-eyed vireo in northwestern Wisco
Bernard (1967) described this species as a "regular but generally uncom
summer resident" in Douglas County. Breeding Bird Survey data (Tab
indicate a fairly constant abundance throughout the Valley. Nesting
been documented in all counties.

Habitat: Characteristic nesting species of mature Lowland Decid
Forest. Highest breeding densities occur in that habitat and mature N
ern Hardwood Forest. Other habitats frequently used include Sout
Deciduous Forest, Deciduous Clear Cuts, and Residential Habitats.

FAMILY PARULIDAE: Wood Warblers

Black-and-white Warbler (*Mniotilta varia*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant throughout the Valley. Jackson (1
reported that the black-and-white warbler was "the most abundar
warblers" during the 1919 spring migration in Polk and Burnett cour
Earliest spring migrants arrive in the Western Upland during the
5 days of April, reaching the Northern Highland 1–5 May. Peak migr
occurs 10–20 May, and nonbreeders depart by 25 May. Fall migr
begins in mid-August and birds reach the Western Upland 20–25 Au
Peak fall migration occurs 10–20 September, and most have departe
5 October.

Nesting Season Distribution: Uncommon and local nesting species, mos
quently encountered in the Northern Highland. Green and Janssen (1
indicated the breeding range of this warbler extended into northern W
ington County. My Minnesota breeding season records have been obt
only in southern Pine County. Confirmed nesting records exist only for
County (12 June 1975). Breeding Bird Survey data (Table 6) suggest a
increase in relative abundance moving northeast through the Valley. Th
year mean number of males recorded on Dresser BBS is <0.1, increasi
1.3 on the Loraine BBS, and 6.9 on Minong.

Habitat: Territorial males have been recorded in both deciduous and c
erous habitats during the breeding season. In deciduous areas, a prefe
is shown for mature Northern Deciduous Forest, characterized by exte
stands of maple and basswood. This species apparently prefers Nort

ferous Forest, Black Spruce–Tamarack Bog, and white cedar com-
ities.

thonotary Warbler (*Protonotaria citrea*)

us: Regular migrant and nesting species.

ation: Rare migrant in the Western Upland; one record from the
ral Plain (7 May 1966, Chisago County). Observations of this warbler
nsufficient to determine patterns of spring and fall migration. Most
ds appear to be birds on or near potential nesting territories. Spring mi-
ts are usually first recorded 10–15 May (earliest—4 May 1974, Pierce
ty). Records of fall migrants are even more irregular; the latest is
ptember 1975 (St. Croix County). Most observations of this bird during
ation periods have been restricted to areas along and adjacent to the St.
River in Pierce, St. Croix, and Washington counties.

ing Season Distribution: Very rare nesting species, apparently re-
ed to the Western Upland. Maurer (1970) briefly described the observa-
f a nest near Marine-on-St. Croix (Washington County) containing one
g on 5 July 1970. On 10 July 1945, 11 male prothonotary warblers were
l on territory between Marine-on-St. Croix and Stillwater, and three
les were observed feeding near nests (Hubert 1945). On 28 June 1945, a
male was observed along the St. Croix River near Osceola, Polk
ty. Observations of territorial males along the lower reaches of the Kin-
nic, Willow, and Apple rivers provide evidence of possible additional
ing records.

at: The prothonotary warbler is restricted almost entirely to large
s of mature Lowland Deciduous Forest dominated by cottonwood,
ash, and American elm. The brief description of the habitat near the
Maurer observed suggests a mixture of willow and basswood.

n-eating Warbler (*Helmitheros vermivorus*)

s: Casual, three spring records.

ds: S. D. Robbins heard and saw one male along Trout Brook Road
Hudson, St. Croix County, on 18 May 1969 (Faanes and Goddard 1976).
r (1969) described the observation of a worm-eating warbler in Wash-
County on 18 May 1969. I observed one near Trout Brook Road in St.
County on 18 May 1980. This species has been recorded with in-
ng frequency in central Minnesota and southern Wisconsin and may
e more regular in the lower reaches of the Valley.

n-winged Warbler (*Vermivora chrysoptera*)

: Regular migrant and nesting species.

tion: Uncommon migrant throughout the Valley. Spring migrants
in the Western Upland 5–10 May, and reach the Northern Highland

about 15 May. Jackson (1943) reported that golden-winged warblers w “common” along the St. Croix River near St. Croix Falls from 21–25 M 1919. One pair was observed copulating on 22 May 1919. This warbler ap ently migrates singly, or in small very loose flocks; thus periods of p spring abundance are difficult to determine. Spring migrants have depa nonbreeding areas in the Western Upland by 30 May. Fall migrants re the Western Upland about 10 August. Peak fall movements o 20 August to 5 September. Departure from the Northern Highland oc by 5 September and elsewhere by 15 September.

Nesting Season Distribution: Uncommon and local breeding bird in Central Plain and Northern Highland. One nest record from the Wes Upland (12 June 1976; River Falls, St. Croix County). Confirmed bree records exist for St. Croix and Polk counties. Green and Janssen (1975) c inferred breeding records for Chisago and Pine counties, although golden-winged warbler was referred to as “quite numerous” in Pine Co during the nesting season. One was reported from Washington Count 5 July 1970 (Russell 1970). Breeding Bird Survey data (Table 6) suggest the center of their breeding range is in the Central Plain.

Habitat: Golden-winged warblers appear to be characteristic of sec growth deciduous forest in early developmental stages. Data from ne Barron County (Wisconsin) show that largest densities occur in Decid Clear Cuts that are less than 10 years old (9 pairs per 40 ha). This densit creases to <0.1 pair per 40 ha in mature aspen–maple woods over 40 y old. Breeding golden-winged warblers also use brushy edges of retired a cultural fields, openings in spruce woods, and occasionally B Spruce–Tamarack Bogs. Golden-winged warblers apparently avoid pine habitat; this warbler has yet to be recorded along the Union BBS r (Burnett County) which traverses extensive stands of jack pine forest.

Blue-winged Warbler (*Vermivora pinus*)

Status: Regular migrant and nesting species.

Migration: Rare migrant in the Western Upland, virtually absent elsewh Most observations consist of birds on or near presumed breeding territo Spring migrants arrive 15–20 May, becoming most conspicuous 25 Ma 5 June. One spring record exists for Burnett County, 20 May 1956 (So ern 1960). Breeding birds disperse early from the breeding areas. The la fall date is 15 September 1975 (St. Croix County).

Nesting Season Distribution: Rare and local breeding bird in the Wes Upland. Green and Janssen (1975) provided the only evidence of confir breeding for the Valley (Washington County). Breeding season birds largely restricted to areas along major river systems, including the nickinnic, Willow, and lower St. Croix. The northern limit of blue-wi warbler breeding range in Wisconsin and Minnesota closely approxim the southern limit of its congener, the golden-winged warbler. As with o regions of limited overlap, hybrids of these species have been obser Manley Olson observed a hybrid referable to “Brewster's warbler”

1 May 1967 in St. Croix County. Olyphant (1973) banded a Brewster's arbler in Washington County on 13 July 1973.

abitat: In this region, breeding blue-winged warblers are characteristic of xtensive stands of mature Lowland Deciduous Forest. Typical vegetation f their breeding habitat includes cottonwood, American elm, and green ash s dominants. Ground-layer vegetation in many situations is usually wood ettle and various grasses. Along the lower Willow River near Hudson, a mall group of breeding blue-winged warblers use a savannah-like asso- ation of Hill's oak and little bluestem. Brushy fields with invading saplings r scattered trees are also used.

ennessee Warbler (*Vermivora peregrina*)

tatus: Regular migrant.

igration: Common migrant throughout the Valley. Mean date of spring rival in the Western Upland is 4 May (earliest—25 April 1948, Polk ounty; Robbins 1948*c*). Arrival in the Northern Highland occurs -15 May. Peak spring migration through the Valley occurs 10-25 May. eparture of spring migrants in the Western Upland and Central Plain curs 25-30 May. In the Northern Highland, stragglers can still be found ntil 10 June. Several mid-June records that suggest possible breeding exist r the Solon Springs area. However, there are no known breeding records of is bird in Wisconsin.

The Tennessee warbler is among the earliest fall migrants of this family, ually arriving in the Northern Highland 15-20 July, reaching the Central lain and Western Upland 25 July to 1 August. Peak fall migration occurs August to 15 September. This warbler has departed the Northern High- nd by 25 September and elsewhere by 5 October (latest—12 October 1961, . Croix County).

abitat: Migrant Tennessee warblers regularly use both deciduous and niferous woods. Perhaps because of its abundance, this warbler is also gularly encountered in residential shrubbery. At the peak of migration, is species congregates in tall trees in residential areas. Six to 10 males per ock is not unusual on a peak day. Most mid-June records have been of rds in Northern Hardwood Forest, Lowland Coniferous Forest, and Black ruce-Tamarack Bogs.

range-crowned Warbler (*Vermivora celata*)

tatus: Regular migrant.

igration: Fairly common migrant in the Western Upland and Central lain, uncommon in the Northern Highland. Spring migrants arrive in the estern Upland 25 April to 1 May (earliest—22 April 1949, Burnett ounty), reaching the Northern Highland 5-10 May. Peak spring migration curs 10-20 May and departure by 25 May. Fall migrants arrive 1-5 Sep- mber. Peak fall migration occurs 20 September to 5 October and de- rture by 10 October (latest—18 October 1976, St. Croix County).

Habitat: Most observations of orange-crowned warblers have been in deciduous woods of various early successional stages. Occasional individuals have been observed foraging at the edge of cattail marshes, primarily during spring migration.

Nashville Warbler (*Vermivora ruficapilla*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley, locally abundant in coniferous habitats of the Northern Highland. Spring migrants begin to arrive in the Western Upland about 1 May, reaching the Northern Highland 10–15 May. Peak spring migration occurs 10–20 May and departure of nonbreeders by 30 May. Fall migration begins with family dispersal in early August; however, the first obvious migratory movements occur after 10 August. The first fall migrants reach the Western Upland about 20 August (earliest—14 August 1963, St. Croix County). Peak fall migration occurs 1–15 September and departure by 5 October (latest—19 October 1968, Pine County).

Nesting Season Distribution: Common breeding bird throughout the Northern Highland; less common and more localized in the Central Plain. No breeding records exist for the Western Upland. Jackson (1943) referred to the Nashville Warbler as "one of the most plentiful Warblers in summer in most of the region" in 1919. Breeding Bird Survey data (Table 6) demonstrate the rapid increase in relative abundance moving northward from the Central Plain.

Habitat: Breeding Nashville warblers have been recorded in a variety of deciduous and coniferous habitats. Greatest use appears to be in coniferous habitats and of these Black Spruce–Tamarack Bogs are probably the most important.

Northern Parula (*Parula americana*)

Status: Regular migrant and summer resident.

Migration: Rare and local migrant in the Western Upland and Central Plain, uncommon in the Northern Highland. Spring migrants arrive 5–10 May in the Western Upland, reaching the Northern Highland 10–15 May. Because of the low numbers recorded, no peak dates have been determined. Departure from the southern regions occurs by 20 May. Fall migration is diffuse as very few birds were recorded each year. Available data suggest that the main period of migration extends from 20 August to 20 September.

Nesting Season Distribution: Rare and local summer resident of the Northern Highland. Available records suggest the main part of their breeding range lies north of the St. Croix River in Douglas and Pine counties. The only Breeding Bird Survey route in the Valley that has recorded this species is the Minong route in Douglas County.

Habitat: Although confirmed nest records are lacking, this species undoubtedly breeds in the Valley. Northern parula observations during the breeding season consist of birds using Lowland Coniferous Forest dominated by a mixture of white cedar, balsam fir, and black spruce. Also typical of their breeding habitat is *Unsea* moss which is used in nest construction.

Yellow Warbler (*Dendroica petechia*)

Status: Regular migrant and nesting species.

Migration: Common spring migrant in all regions; fairly common during fall. Spring migrants arrive in the Western Upland 1–5 May and reach the Northern Highland by 10 May. Peak spring abundance occurs 10–20 May. Fall migration begins with dispersal from breeding areas in late July. The first large fall movement of yellow warblers occurs 1–5 August. Peak fall movements are noted 10–25 August and departure by 5 September.

Nesting Season Distribution: Common breeding species throughout the region with confirmed breeding records from all counties. Jackson (1943) reported that yellow warblers were uncommon breeding birds at the headwaters of the St. Croix River in 1919. Breeding Bird Survey data (Table 6) suggest that the center of yellow warbler abundance in the Valley is in the Central Plain. Goddard (1972) reported a breeding density of 3.4 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Habitat: This warbler appears to use a wide range of habitats, including second-growth deciduous and coniferous woodland, Deciduous Clear Cuts, Black Spruce-Tamarack Bogs, Alder Thicket, Shrub Carr, and edge of various natural basin wetlands. Although seemingly ubiquitous in breeding habitat use, it appears that the yellow warbler demonstrates a strong preference for wetland and wetland-associated habitats.

Magnolia Warbler (*Dendroica magnolia*)

Status: Regular migrant and summer resident.

Migration: Fairly common migrant in all regions. Spring migrants arrive in he Western Upland 5–10 May (earliest—1 May 1969, Washington County) nd reach the Northern Highland about 15 May. Peak spring migration occurs 15–25 May but stragglers remain until 1 June. Fall migrants arrive n the Northern Highland 15–20 August and the Western Upland about 0 August (earliest—15 August 1976, Washington County). Peak fall migraion occurs 5–20 September and departure by 1 October (latest—21 October 955, Polk County; Foster 1956).

Nesting Season Distribution: Rare and local summer resident, restricted to he Northern Highland. Several summer records (16 June 1973, 28 June 974, and 12 June 1977 from along the St. Croix River in Douglas County, nd 10 June 1977 along the St. Croix in Pine County) suggest the possibility f nesting. Bernard (1967) considered the magnolia warbler a rare summer esident in Douglas County, but provided no evidence of nests.

Habitat: Migrant magnolia warblers occupy a wide range of both deciduous and coniferous habitats. This species is most frequently encountered during migration in early successional stages of northern upland deciduous forest and in Deciduous Clear Cuts. My observations of this warbler during the breeding season have been confined to extensive stands of Black Spruce–Tamarack Bog. This habitat type appears to be used extensively for nesting within their normal breeding range in northern Minnesota and Wisconsin.

Cape May Warbler (*Dendroica tigrina*)

Status: Regular migrant, one summer record.

Migration: Uncommon to rare migrant in the Western Upland and Central Plain, uncommon to locally common migrant in the Northern Highland. Spring migrants arrive in the Western Upland 5–10 May, reaching the Northern Highland about 15 May. During spring migration, Cape May warblers are most regularly observed 15–25 May and have departed by 1 June. Robbins (1973) provided the only summer record for the Valley, a singing male 1.6 km north of Gordon, Douglas County, on 16 June 1971. Fall migration begins in mid-August with first arrivals in the Central Plain about 20 August. During fall they are regularly encountered from 25 August to 10 September and depart by 25 September (latest—29 September 1965, Washington County).

Habitat: Migrant Cape May warblers use various age classes of coniferous habitats and early successional stage deciduous habitats. In residential areas, this species is also attracted to blossoming apple trees and ornamental spruces. Robbins (1973) described the habitat of a group of nesting Cape May warblers along the Brule River as black spruce. The area that Robbins described is 8.0 km north of Solon Springs, Douglas County, and within 4.8 km of the St. Croix River watershed. Because extensive stands of similar black spruce habitat exist along the St. Croix near Solon Springs, I would expect that additional birds could be located. However, to date I have been unsuccessful in finding this warbler during the breeding season along the St. Croix River.

Black-throated Blue Warbler (*Dendroica caerulescens*)

Status: Regular migrant, occasional summer resident.

Migration: Rare migrant throughout the Valley. Most records are from directly adjacent to the St. Croix River. Spring migrants arrive 5–10 May (earliest—2 May 1972, Washington County) and have departed by 25 May. Fall records tend to indicate that this warbler occurs more commonly during that period. Fall migrants arrive 30 August to 5 September. Records indicate that peak fall numbers occur 15–25 September and departure by 30 September (latest—21 October 1961, Polk County).

Nesting Season Distribution: The only evidence of summer residence is provided by Green and Janssen (1975) who reported the most southerly summer records in Minnesota are from "northern Pine County." I have obtained no summer records of this bird within the Valley in Minnesota or Wisconsin. However, during 5–30 June 1971, I regularly observed three pairs of black-throated blue warblers in Bayfield County about 24 km east of Solon Springs. These observations suggest that breeding black-throated blue warblers may also occur in suitable habitat along the northern reaches of the St. Croix River.

Habitat: During migration, this warbler is most common in wet or mesic deciduous forest sites. I have only one record from xeric Southern Deciduous Forest that was dominated by red oak. Observations of black-throated blue warblers during the breeding season in Bayfield County, Wisconsin, were in extensive stands of mature maple–basswood–aspen forest.

Yellow-rumped Warbler (*Dendroica coronata*)

Status: Regular migrant and nesting species, occasional winter resident.

Migration: Abundant migrant throughout the Valley. The yellow-rumped warbler is the most numerous warbler in this region. Spring migrants arrive in the Western Upland about 5 April (earliest—21 March 1975, Pierce County; 24 March 1963, St. Croix County). Migrants reach the Northern Highland 10–15 April. Peak spring migration through the Valley extends from 20 April to 10 May. Departure from nonbreeding areas occurs by 15 May (latest—24 May 1971, Washington County). Fall migration begins in the Northern Highland 15–20 August; however, the first fall migrants do not reach the Western Upland until 10 September. Peak fall migration occurs 20 September to 5 October. Departure from the Northern Highland occurs by 15 October; 1 November is the usual departure date elsewhere. Occasional stragglers remain in the Western Upland through November. Late dates include 30 November 1975, Pierce County and 3 December 1961, St. Croix County.

Nesting Season Distribution: Rare and local breeding bird, restricted primarily to the Northern Highland. Green and Janssen (1975) showed that the breeding range of this warbler extended into northwestern Pine County. Jackson (1943) did not record breeding season yellow-rumped warblers in the Valley during 1919. Breeding Bird Survey data (Table 6) show that a limited number of yellow-rumped warblers occur along the route of the Minong BBS transect in Douglas County.

On 24 June 1974 and 11 June 1977, I recorded singing yellow-rumped warblers along the St. Croix River in Sec. 23, T. 43 N., R. 14 W., Douglas County, and one singing male was recorded along the St. Croix River in Pine County at the U.S. Highway 77 crossing 4.8 km west of Danbury. Singing and behavioral activities suggested nesting, although nests or young were not observed.

Winter: The only record of an overwintering yellow-rumped warbler is that of one bird remaining at a feeder near River Falls, St. Croix County, during the 1960–61 winter (Faanes and Goddard 1976). Two additional early winter records exist from the Afton CBC: 1 January 1970 (St. Croix County) and

1 January 1975 (Washington County). It is not known if these birds remained throughout the winter.

Habitat: During migration, this warbler is ubiquitous, occurring in essentially all available habitats. Breeding season records include birds from extensive stands of Lowland Coniferous Forest, dominated by white spruce, from Black Spruce–Tamarack Bogs, Jack Pine Barren, and areas of mature white pine. Both habitats are used extensively by nesting yellow-rumped warblers within their normal breeding range in northern Minnesota and Wisconsin.

Black-throated Green Warbler (*Dendroica virens*)

Status: Regular migrant and nesting species.

Migration: Uncommon migrant throughout the Valley, locally common in the Northern Highland. Spring migrants arrive in the Western Upland 5–10 May, reaching the Northern Highland 10–15 May. Peak spring migration occurs 15–25 May and nonbreeders have departed by 30 May. Fall migration begins in the Northern Highland 15–20 August and the first migrants reach the Western Upland 25–30 August. Peak fall migration occurs 5–20 September and departure by 5 October (latest—7 October 1973, St. Croix County).

Nesting Season Distribution: Uncommon breeding bird in the Northern Highland. Rare and local in southern Pine, Burnett, and northern Polk and Chisago Counties. Jackson (1943) reported this warbler as "not uncommon" at Solon Springs, Douglas County. On BBS transects (Table 6) black-throated green warblers have been recorded only on the Minong route, Douglas County. This warbler was recorded on 9 June 1973 in Chisago County (Longley 1973*b*), but no evidence of nesting was obtained.

Habitat: Mature Northern Hardwood Forest dominated by sugar maple, basswood, and trembling aspen is used extensively. The large expanses of Lowland Coniferous Forest, primarily adjacent to the upper St. Croix River, are also important.

Cerulean Warbler (*Dendroica cerulea*)

Status: Regular migrant and nesting species.

Migration: Rare spring and fall migrant, restricted primarily to the Western Upland and a small region of the Central Plain. Spring migrants begin to arrive 10–15 May. Most observations are after 15 May and are probably of birds on breeding territories. Data are too few to establish fall migration periods. The latest date available is 16 August 1974 in St. Croix County.

Nesting Season Distribution: Rare and local breeding bird. Confirmed nest records exist only for St. Croix County. On 23 June 1976, I observed adults feeding two young in the nest along the Willow River near Hudson (T. 29 N., R. 19 W.). Cerulean warblers occur regularly only in the lower reaches of the Kinnickinnic River (Pierce County) and Willow River (St. Croix County) and near Afton State Park (Washington County). Occasional breeding season records have been obtained at the mouth of the Apple River (St. Croix County) and from lowland forest at Marine-on-St. Croix (Washington County). Records away from the typical range of this warbler in the Valley include two singing males on 2 June 1968 at Franconia, Chisago County, one in Chisago County on 6 June 1971, and one male near Range, Polk County, on 15 June 1968.

Habitat: Breeding season observations of this warbler have been restricted to Lowland Deciduous Forest. Predominant vegetation of these areas include mature stands of American elm, cottonwood, and green ash.

Blackburnian Warbler (*Dendroica fusca*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant in the Western Upland and Central Plain, common in the Northern Highland. Spring migrants arrive 5–10 May, reaching the Northern Highland 10–12 May. Peak spring migration occurs 15–25 May and departure from nonbreeding areas by 30 May. Jackson (1943) considered this warbler "abundant" at St. Croix Falls (Polk County) 21–25 May 1919. Fall migration begins 10–15 August and the first birds reach the Western Upland about 20 August. Peak fall migration occurs 5–15 September and birds depart by 25 September.

Nesting Season Distribution: Uncommon breeding bird, restricted to the Northern Highland. Breeding season records exist for Burnett, Douglas, and Pine counties. The only confirmed nest records are from Pine (Green and Janssen 1975) and Douglas (Chambers 1944) counties. However, it undoubtedly nests elsewhere in the Northern Highland. Jackson (1943) reported that courting Blackburnian warblers were observed at St. Croix Falls on 24 May 1919. He noted that "although no nests were discovered . . . , the environment is favorable for nesting." Breeding Bird Survey data (Table 6) indicate that this bird occurs in relatively low densities during the breeding season in the Northern Highland.

Habitat: The Blackburnian warbler is characteristic of northern coniferous forests. Territorial birds are encountered most regularly in large tracts of Lowland Coniferous Forest dominated by black spruce, white cedar, and hemlock. Breeding birds also use Black Spruce–Tamarack Bogs and white pine forest where remnants still exist.

Chestnut-sided Warbler (*Dendroica pensylvanica*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. The mean date of spring arrival in the Western Upland is 8 May (earliest—2 May 1974, Pierce County) and arrival in the Northern Highland by 12 May. Peak migration occurs 10–25 May and birds have departed nonbreeding areas by 30 May. Fall migration begins in the Northern Highland 5–10 August with dispersal of young, and the first migrants reach the Western Upland 15–20 August. Peak migration occurs 1–15 September. Departure from the Northern Highland occurs 15–20 September and elsewhere by 1 October (latest—5 October 1973, St. Croix County).

Nesting Season Distribution: Common breeding bird in the Northern Highland and that part of the Central Plain north of St. Croix Falls and Taylor's Falls. South of that line, they are uncommon and local, and rare and local in the Western Upland. Green and Janssen (1975) showed that the breeding range of this warbler extended through the three Minnesota counties. On 26 June 1979, I heard and saw territorial males 4.8 km west of Taylor's Falls, Chisago County. Although nests or young were not observed, I have no doubt they nested in this area.

Nests or young have been recorded in all subject Wisconsin counties except Pierce. An area near the Cylon Marsh Wildlife Area (Sec. 15, T. 31 N., R. 16 W.) and at the mouth of the Apple River (Sec. 20, T. 31 N., R. 19 W.), St. Croix County, are the most southerly locations of regular occurrence. Jackson (1943) recorded this warbler only "occasionally" in the Northern Highland near Solon Springs in 1919, but BBS data (Table 6) show that breeding chestnut-sided warblers occur commonly throughout the Valley and that largest densities are in the Northern Highland.

Habitat: Early successional stages of deciduous and coniferous habitats are used for nesting. Deciduous Clear Cuts that are predominantly aspen support the greatest density of breeding chestnut-sided warblers. Northern Hardwood Forest that is dominated by maple–basswood–aspen is also important. Recent attempts by State wildlife agencies to retard vegetational succession by clear-cutting or selectively logging mature deciduous forest are beneficial for this warbler.

Bay-breasted Warbler (*Dendroica castanea*)

Status: Regular migrant.

Migration: Uncommon to rare spring migrant in the Western Upland and Central Plain; fairly common in the Northern Highland. Common fall migrant throughout the Valley. Spring migrants arrive in the Western Upland 8–12 May, reaching the Northern Highland about 15 May. Peak migration occurs 15–25 May and departure by 1 June. Jackson (1943) reported that the collection of a female bay-breasted warbler at Danbury, Douglas County, on 27 May 1919 was the only spring record obtained in northwestern Wisconsin that year. Fall migrants arrive in the Northern Highland in late July, reaching the Western Upland 10–15 August. Peak fall migration occurs 1–20 September. Departure from the Northern Highland occurs 20–25 September and elsewhere by 1 October (latest—19 October 1968, Chisago County).

Habitat: Bay-breasted warblers occupy a wide range of deciduous and coniferous habitats. In the Northern Highland they are most regularly observed in Lowland Coniferous Forest or Black Spruce–Tamarack Bog.

Blackpoll Warbler (*Dendroica striata*)

Status: Regular migrant.

Migration: Common migrant throughout the Valley. Spring migrants arrive n the Western Upland 5-10 May (earliest—30 April 1967; 1 May 1969, Washington County) and the Northern Highland 10-15 May. Peak spring migration occurs 15-25 May and departure is by 30 May (latest—2 June 970, Washington County). Fall migrants arrive in the Northern Highland 0-15 August and reach the Western Upland 15-20 August. Peak fall migration occurs 30 August to 20 September and departure 25-30 September.

Habitat: Although both deciduous and coniferous forest habitats are regularly used, this warbler is the most common in mature deciduous forest.

Pine Warbler (*Dendroica pinus*)

Status: Regular migrant and nesting species.

Migration: Uncommon to rare migrant throughout the Valley. Jackson 1943) found this warbler not as plentiful as anticipated in 1919. However, they were considered "common" at Danbury, Burnett County, 27-30 May 919. Spring migrants arrive in the Western Upland 1-5 May and the Northern Highland 5-10 May. This species is most frequently encountered 0-20 May. Departure from nonbreeding areas occurs by 25 May. Fall migration begins in the Northern Highland 10-15 August and the first birds reach the Western Upland 20-30 August. This species is most frequently ncountered 1-15 September and they have departed by 1 October.

Nesting Season Distribution: Uncommon breeding species in the Northern Highland, rare and local in the Central Plain. Breeding Bird Survey data Table 6) also suggest that this species is in the Western Upland during the esting season. Although breeding season records exist for all areas except ierce and Washington counties, confirmed nest records exist only for Pine ounty. Territorial birds were recorded in Chisago County during the summers of 1973-74 and 1976. The only location of regular occurrence in St. roix County is near Burkhardt (Sec. 3, T. 29 N., R. 19 W.).

Habitat: Characteristic nesting species of remnant white pine forest. Although regularly recorded in Jack Pine Barrens, Breeding Bird Survey data r the Union transect (Burnett County) suggest that low densities occur in hat habitat.

alm Warbler (*Dendroica palmarum*)

Status: Regular migrant, probable nesting species.

Migration: Abundant migrant throughout the Valley, probably second only the yellow-rumped warbler in overall abundance. Spring migrants arrive the Western Upland 25 April to 1 May, reaching the Northern Highland -5 May. Peak migration occurs 5-15 May and departure by 25 May. A nging male in Chisago County on 4 June 1968 was undoubtedly a very late migrant. Fall migrants arrive in the Northern Highland 20–25 August and the Central Plain 25 August to 5 September. Peak fall migration occurs 10–25 September and birds depart by 10 October (latest—25 October 1968, Chisago County).

Nesting Season Distribution: This species probably nests in Douglas County (S. D. Robbins, personal communication). On 27 June 1966, Robbins heard a singing male palm warbler in a bog in Sec. 35, T. 43 N., R. 12 W. On 26 June 1974 a male was heard in Sec. 23, T. 43 N., R. 12 W. On the same date another male palm warbler was recorded in a large open bog 6.4 km north of Moose Junction (T. 44 N., R. 14 W.).

Habitat: In the Western Upland and Central Plain, palm warblers occupy medium-aged deciduous forest extensively. Alder Thicket and Shrub Carr are also important. In the Northern Highland, extensive use is made of Lowland Coniferous Forest, Black Spruce–Tamarack Bogs, and sedge meadow. Nesting season records are of birds in open Black Spruce–Tamarack Bogs.

Ovenbird (*Seiurus aurocapillus*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants arrive in the Western Upland about 1 May and the Northern Highland 5–10 May. Peak spring migration occurs 10–20 May. Departure from nonbreeding areas of the Western Upland occurs by 25 May. Peak fall migration is 1 September (Northern Highland) to 10 September (Western Upland) and departure is by 1 October.

Nesting Season Distribution: Common to locally abundant breeding bird in the Northern Highland and Central Plain. Uncommon and local in the Western Upland. Breeding Bird Survey data (Table 6) indicate that this warbler occurs in greatest numbers in the Northern Highland and Central Plain. Jackson (1943) referred to the ovenbird as the characteristic and often dominant breeding bird in heavier deciduous forest (= mature Northern Hardwood). Goddard (1972) reported the ovenbird was the most abundant breeding warbler in the Lower Kinnickinnic River Valley, Pierce County.

Habitat: Characteristic nesting species of mature Northern Hardwood Forest, where the predominant tree species include sugar maple, basswood, trembling aspen, and white birch. In the Western Upland, breeding ovenbirds are associated with red oak–Hill's oak forest. Remnant stands of mixed red pine and white pine are regularly used in the northern regions.

Northern Waterthrush (*Seiurus noveboracensis*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant in the Western Upland and Central Plain, locally common in the Northern Highland. Spring migrants arrive 1–5 May, reaching the Northern Highland 5–10 May. Peak migration occurs 10–20 May and departure from nonbreeding areas is by 30 May. Fall migrants arrive in the Northern Highland about 5 August, reaching the Western Upland 20–25 August (earliest—12 August 1962, St. Croix County). Peak fall migration occurs 25 August to 10 September and departure by 30 September.

Nesting Season Distribution: Rare and local breeding species, occurring primarily in the Northern Highland. Most observations of nesting season northern waterthrushes have been in habitats along and adjacent to the St. Croix River in Douglas, Burnett, and Pine counties. Breeding Bird Survey data show the low breeding density of this species in the Valley. Goddard (1972) reported a northern waterthrush during the breeding season along the Kinnickinnic River, Pierce County, in June 1971. If correct, that record would extend the probable breeding range of this species at least 160 km south. The lack of proper habitat, plus the population of Louisiana waterthrush along the river, render that record suspect.

Habitat: This species uses a narrow range of wet habitats in the Northern Highland. Primary breeding habitat includes Lowland Coniferous Forest, Alder Thicket, and Northern Sedge Meadow that is becoming invaded with various shrubs including smooth alder and gray dogwood. During migration in the Western Upland and Central Plain, Lowland Deciduous Forest, Northern Hardwood Forest, and Deciduous Clear Cuts are used extensively, as are shorelines of lakes and streams.

Louisiana Waterthrush (*Seiurus motacilla*)

Status: Regular migrant and nesting species.

Migration: Rare spring migrant in the Western Upland and Central Plain. Records in the Central Plain are restricted to areas south of St. Croix Falls and Taylor's Falls. No well-defined pattern of spring migration can be estabished. Most birds observed appear to be on established breeding territories. Most spring individuals occur 10–30 May (earliest—27 April 1964 [Soulen 1965], 2 May 1948, and 3 May 1966; Washington County). Fall migration is early and diffuse (latest—23 August 1974, Chisago County; 11 September .972, St. Croix County).

Nesting Season Distribution: Rare and local nesting species of the Western Jpland and Central Plain. Confirmed breeding records exist for Chisago Green and Janssen 1975), Washington, and St. Croix counties. Breeding eason birds have also been recorded in Pierce and Polk counties; however, nest records are lacking.

Probably the best-known breeding area in the Valley for Louisiana waterhrush is along Lawrence Creek near Franconia, Chisago County. Longley 973*b*) described the first known breeding record of this bird at that locaon, when a nest containing two young cowbirds, one young Louisiana aterthrush, and one addled egg was found near Franconia on 9 June 1973. n June 1968 Longley (1973*b*) recorded six singing males at this same locally. One Louisiana waterthrush was also recorded at that location in 974–76 and a nest was found in 1975.

Another well-known nesting area is along the lower Willow River near the

Trout Brook Road bridge at Hudson, St. Croix County. At that location, Louisiana waterthrush has been recorded in the breeding season intermittently since 1960. On 3 June 1974 I recorded singing males at four locations along a 300-m reach of this stream. Returning on 5 June 1975, I located two singing males and found one nest containing three eggs; their outcome is unknown.

Elsewhere, records from Washington County include one nest at Stillwater on 10 July 1943 (Chambers 1944) and a nest containing five young on 17 June 1945 (Lupient 1945). Roberts (1938) described the observation of a nest and young along the St. Croix River below Taylor's Falls, Chisago County, on 2–4 July 1927. Goddard (1972) reported this species during June 1971 along the Lower Kinnickinnic River, Pierce County. In the area near the mouth of that river, two to three singing males have been recorded yearly in June 1973–78, but no nest has been found.

Habitat: Rich stands of Lowland Deciduous Forest along fast-moving streams. The St. Croix County nest was located beneath an overhanging root of American elm, less than 1 m from water's edge.

Kentucky Warbler (*Oporornis formosus*)

Status: Casual, two records.

Record: S. D. Robbins observed a male Kentucky warbler near Roberts, St. Croix County, on 28 May 1963 (Faanes and Goddard 1976). This observation represents the most northerly record of this warbler in Wisconsin. Glassel (1977) described the observation of a singing male Kentucky warbler on 17 June 1977 at Afton State Park, Washington County. The bird remained in the area at least until 19 June 1977.

Connecticut Warbler (*Oporornis agilis*)

Status: Regular migrant and nesting species.

Migration: Rare spring and uncommon fall migrant throughout the Valley. Spring migrants arrive in the Western Upland 15–20 May (earliest—4 May 1974, Pierce County), and reach the Northern Highland about 25 May. During spring they are most frequently observed 25 May to 5 June and depart by 10 June. Fall migrants arrive 15–20 August in the Northern Highland and 20–25 August in the Western Upland. Peak fall migration occurs 5–15 September and they depart by 25 September. Roberts (1938) mentioned the observation of "several" Connecticut warblers in Pine County during the first week of October 1929.

Nesting Season Distribution: Rare and local during the nesting season. Gromme (1941) described the only confirmed breeding of this warbler in the Valley; a nest containing four young on 7 July 1941, near Gordon, Douglas County (T. 43 N., R. 13 W.). Green and Janssen (1975) showed that the nesting range of this warbler in Minnesota reached northern Pine County. Breeding Bird Survey data (Table 6) suggest that a fairly large breeding population exists in southern Douglas County (Sec. 11, 12, 13, 14, T. 43 N.,

R. 12 W.; Robbins 1974*a*). Another population is known to occur in northwestern Burnett County near Grantsburg.

Habitat: Bent (1953) described the breeding habitat of the Connecticut warbler as consisting of tamarack bogs or wet coniferous forest. However, Robbins (1974*a*) reported this warbler in fairly large densities in monotypic stands of jack pine. Further description of this habitat indicates the trees were 4–9 m high and had well-developed lower branches. Trees < 4.6 m tall or those with a scarcity of lower branches were not used by breeding Connecticut warblers. Robbins' observation of nesting in jack pine is further substantiated by recent (1974–78) records from the Union BBS transect, Burnett County. The habitat along this route also consists of large tracts of jack pine, and Connecticut warblers have been found regularly there.

Mourning Warbler (*Oporornis philadelphia*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant throughout the Valley. Spring migrants arrive in the Western Upland 10–15 May and reach the Northern Highland 15–20 May. Peak spring migration occurs 25 May to 5 June and departure rom nonbreeding areas by 10 June. Fall migrants arrive in the Western Upland 20–25 August. Peak fall migration through the Valley occurs 5–15 September and departure by 25 September (latest—29 September 965, Washington County).

Nesting Season Distribution: Fairly common (locally common) breeding bird in the Northern Highland and the northern half of the Central Plain. Elsewhere, the mourning warbler is uncommon to rare during the nesting season. A nest with young observed in Washington County on 11 and 13 July 1975 Eckert 1975) represents the southernmost breeding record in the Valley. Breeding Bird Survey data (Table 6) also suggest that the mourning warbler reeding population increases with latitude through the Valley.

Habitat: Characteristic breeding habitat of the mourning warbler includes Northern Hardwood Forest and Deciduous Clear Cuts. Primary nesting abitat of this warbler appears to be areas of dense understory in mature tands of deciduous forest, such as those resulting from openings in the verstory that allow ample sunlight to penetrate. The edge between medium-aged aspen forest and open fields or highway rights-of-way are also nportant habitats. I have not recorded this warbler in coniferous habitats uring the breeding season.

Common Yellowthroat (*Geothlypis trichas*)

tatus: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants arrive n the Western Upland 1–5 May and the Northern Highland about 10 May. eak spring migration occurs 10–20 May. Fall migration begins about 5 August. Peak fall migration through the Valley occurs 5–20 September nd departure by 5 October (latest—17 October 1955, Polk County).

Nesting Season Distribution: Abundant and well-distributed breeding bird in all regions. Confirmed nest records have been obtained from all counties. Goddard (1972) reported that the common yellowthroat was the second most abundant breeding warbler in the Kinnickinnic River Valley, Pierce County. Breeding Bird Survey data (Table 6) suggest that the common yellowthroat is the most obvious, if not the most abundant, breeding warbler in the Valley. The greatest relative abundance occurs in the Northern Highland and in northern areas of the Central Plain.

Habitat: The common yellowthroat is nearly unlimited in its choice of nesting habitat. Jackson (1943) found this warbler in "damp brushy woodland." In the Western Upland, common yellowthroats are most abundant in small patches of mixed willow and cottonwood associated with streams or rivers. In the Central Plain, extensive use is made of the cattail–bulrush vegetation associated with seasonally and semipermanently flooded wetlands; Shrub Carr and sedge meadow are also important. In the Northern Highland, this warbler uses Alder Thickets, Northern Sedge Meadows, and Forest Bordered Lakes. Tamarack bogs and Lowland Coniferous Forest are also important. Use of upland habitats include dry upland fields and brushy edge areas.

Yellow-breasted Chat (*Icteria virens*)

Status: Casual migrant and summer resident.

Migration: There are two spring records from St. Croix County: 6 May 1964 and 18 May 1962. Both observations were made along Trout Brook Road near Hudson. One fall record (22–29 September 1948) exists for St. Croix Falls, Polk County (Robbins 1949).

Nesting Season Distribution: S. D. Robbins observed singing male yellow-breasted chats near Hudson and Burkhardt, St. Croix County, on 17 June 1961, 21 June 1963, and 30 June 1964. The habitat associated with these birds consisted of various shrubby plants at the border of agricultural fields and (one bird) the edge of a retired hayfield. These habitats are similar to typical breeding habitat within their normal range. Thus, it is likely at that date that these were males defending territories or at least advertising for a mate.

Habitat: This species is most frequently encountered in the Old Field Community and brushy edges of Southern Deciduous Forest.

Hooded Warbler (*Wilsonia citrina*)

Status: Casual, two spring records.

Records: S. D. Robbins observed a singing male hooded warbler at the entrance to Birkmose Park in Hudson, St. Croix County, on 29 May 1963 (Faanes and Goddard 1976). A male hooded warbler was banded and photographed in Washington County on 2 June 1962 (Olyphant 1962).

Wilson's Warbler (*Wilsonia pusilla*)

Status: Regular migrant.

Migration: Fairly common (locally common) migrant throughout the Valley. Spring migrants arrive in the Western Upland about 10 May (earliest— May 1966, Washington County) and reach the Northern Highland from 0-15 May. Peak spring migration occurs 15-25 May and departure is by June. Fall migrants arrive in the Northern Highland 10-15 August and he Western Upland about 20 August. Peak fall migration occurs 25 August o 10 September and departure is by 25 September (latest—27 September 967, Washington County).

Habitat: Wilson's warbler uses a variety of deciduous and coniferous habiats during migration. Although no single habitat is of major importance, his species is most frequently observed in brushy fencerows, Deciduous lear Cuts, and young to medium-aged Northern Hardwood Forest domiated by trembling aspen and white birch.

anada Warbler (*Wilsonia canadensis*)

tatus: Regular migrant and summer resident.

Migration: Uncommon migrant throughout the Valley. The Canada warbler among the latest arriving warblers during spring migration. The first irds reach the Western Upland 12-15 May and the Northern Highland 5-20 May. Peak spring migration occurs 20-30 May and departure from onbreeding areas by 30 May (latest—2 June 1970, Washington County). he first fall migrants arrive in the Western Upland 5-10 August. Peak fall igration occurs 15 August to 5 September and departure by 15 September atest—29 September 1967, Washington County).

esting Season Distribution: Rare and local during the breeding season, pparently restricted to the Northern Highland. Breeding Bird Survey data able 6) also suggest restriction to the Northern Highland. The breeding nge of this warbler in the Minnesota counties is known to include only orthern Pine County (Green and Janssen 1975).

abitat: Primarily encountered along the edge of Northern Hardwood orest and in Lowland Coniferous Forest during the nesting season. My observations of this bird's breeding habitat suggests that brushy understory ssociated with Northern Hardwood Forest is probably most regularly used. eciduous Clear Cuts in the Northern Highland receive moderate use as es the brushy edge between aspen forest and adjacent open areas.

merican Redstart (*Setophaga ruticilla*)

atus: Regular migrant and nesting species.

gration: Common (locally abundant) migrant throughout the Valley. ring migrants arrive in the Western Upland 1-5 May and reach the rthern Highland 5-10 May. Peak spring migration occurs 10-25 May.

During 1919, Jackson (1943) reported that American redstarts were "the commonest of the warblers" at St. Croix Falls, Polk County, and he found them "abundant" in timber along the St. Croix River. Fall migration begins 5–10 August in the Northern Highland and 20–25 August elsewhere. Peak fall migration occurs 25 August to 15 September and departure is by 5 October (latest—13 October 1966, Washington County).

Nesting Season Distribution: Common nesting species throughout the Valley. Locally abundant in the Western Upland and Central Plain, in areas associated with the mouths of major streams. Goddard (1972) reported a density of 3.9 pairs per 40 ha in the lower Kinnickinnic River Valley, Pierce County. However, his study area was primarily upland deciduous forest, which is not preferred habitat of breeding American redstarts. Breeding Bird Survey data (Table 6) suggest that highest breeding densities occur in the Central Plain and Northern Highland. Unfortunately, this route of survey does not traverse important American redstart habitat directly adjacent to the St. Croix River and its tributaries in the Western Upland.

Habitat: Characteristic breeding bird of Lowland Deciduous Forest in the Western Upland and Central Plain. Vegetation of these areas includes American elm, box elder, green ash, and basswood. Important upland habitat in the Northern Highland includes medium-aged to mature Northern Hardwood Forest that is dominated by basswood, maple, big-toothed aspen, and white birch. Use of coniferous habitats by nesting American redstarts is very light.

FAMILY PLOCEIDAE: Weaver Finches

House Sparrow (*Passer domesticus*)

Status: Introduced permanent resident.

Distribution: Common to locally abundant resident throughout the Valley. The largest concentrations of house sparrows occur in residential areas and other sites of human habitation, including rural residential developments and farms. This species is less numerous and more localized in heavily forested habitats away from the influence of humans.

Habitat: Closely related to areas of human settlement including houses, office buildings, feedmills, railroad tracks, farmyards, feedlots, and pastures.

FAMILY ICTERIDAE: Meadowlarks, Blackbirds, and Orioles

Bobolink (*Dolichonyx oryzivorus*)

Status: Regular migrant and nesting species.

Migration: Common to locally abundant migrant in Western Upland and Central Plain, uncommon and local in the Northern Highland. Spring migrants arrive 25 April to 1 May, reaching northern areas by 10 May. Peak spring migration occurs 10–20 May. Fall migration begins in late July in the Northern Highland and 10–15 August elsewhere. Peak abundance occurs 20–30 August and departure from the Northern Highland by 20 August and 15 September elsewhere.

Nesting Season Distribution: Common to locally abundant nesting species in Western Upland and Central Plain. Rare to uncommon and local in the Northern Highland. Breeding Bird Survey data (Table 7) indicate that a uniformly large breeding population occurs in the Western Upland and Central Plain. Documented breeding records exist for Pierce, St. Croix, and Polk counties. There are inferred breeding records for the remainder of the region. In Douglas County, Bernard (1967) referred to the bobolink as a "common summer resident." Jackson (1943) found this species to be "distributed . . . where meadow environment suitable for them prevails"; however, he provided no data for the Valley.

Habitat: Characteristic species of grassland communities including retired cropland, alfalfa fields, tame pasture, Managed Grasslands, and remnant prairies. Occasionally found using Northern Sedge Meadow and Shrub Carr; however, these habitats apparently receive higher use during migration.

Eastern Meadowlark (*Sturnella magna*)

Status: Regular migrant and nesting species, casual in winter.

Migration: Fairly common migrant east of the St. Croix River, uncommon west of the river. Spring migrants arrive 5–15 March, reaching peak abundance 1–15 April. Fall migration begins in early September in the Northern Highland and by 10 September elsewhere. Peak abundance occurs 25 September to 15 October and departure by 1 November.

Nesting Season Distribution: Fairly common nesting species throughout the Valley; most numerous in eastern segments of the Western Upland and

Table 7. *Mean number of bobolinks, meadowlarks and blackbirds recorded on western Wisconsin Breeding Bird Survey transects, 1966–78.*

	Western Upland	Central Plain		Northern Highland	
Species	Hudson	Dresser	Loraine	Union	Minong
Bobolink	31.0	30.7	37.0	0.1	0.5
Eastern meadowlark	3.4	10.7	22.7	0.0	0.4
Western meadowlark	133.7	73.7	32.2	0.1	0.2
Yellow-headed blackbird	4.1	3.4	1.2	0.1	0.5
Red-winged blackbird	50.0	184.4	203.2	8.7	36.0
Northern oriole	7.3	16.3	12.2	3.7	8.3
Brewer's blackbird	0.0	0.6	1.7	0.2	2.7
Common grackle	43.8	84.6	61.2	0.4	10.5
Brown-headed cowbird	11.2	36.1	33.5	24.4	37.9

Central Plain. Documented nesting records exist from St. Croix and Pierce counties. The eastern meadowlark probably nests in the remainder of the Valley. Breeding Bird Survey data (Table 7) demonstrate a marked increase in relative abundance moving eastward from the St. Croix River. These population indices range from an average of 3.4 per year on the Hudson BBS (St. Croix County), to 22.7 per year on the Loraine BBS (Polk County).

Winter: Several winter records exist for this species, primarily from Washington County. These records include one on the St. Paul Suburban CBC 30 December 1961 and two on this count 30 December 1972. There are two winter records from Wisconsin: three birds that I netted on 16 January 1975 in Pierce County and one bird near Deronda, Polk County, during the 1947–48 winter (Robbins 1948*b*).

Habitat: Eastern meadowlarks occupy a variety of grassland habitats including domestic hayfields, retired croplands, remnants of oak savannah habitats, overgrazed pasture, Old Field Communities, and drier portions of Shrub Carr wetlands.

Western Meadowlark (*Sturnella neglecta*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Common to abundant migrant in the Western Upland and Central Plain, fairly common in the Northern Highland. Spring migrants arrive in the Western Upland 5–10 March and reach the Northern Highland 25 March to 5 April. Peak abundance occurs 25 March to 15 April. Fall migration begins in mid-August in the Northern Highland and by 1 September elsewhere. Peak abundance occurs 20 September to 20 October and departure by 1 November; occasional stragglers remain to 1 December.

Nesting Season Distribution: Common to locally abundant breeding species in all regions. Breeding Bird Survey data (Table 7) demonstrate a marked increase in relative abundance westward through the Valley. Average numbers recorded per route range from <1 in Douglas County (Minong BBS) and 32.2 in Polk County (Loraine BBS) to 133.7 in St. Croix County (Hudson BBS). This trend in breeding population distribution is the reverse of the eastern meadowlark.

Winter: Meadowlarks are fairly regular during winter months in the Western Upland. Many of these records are probably referable to western meadowlark; however, plumages are similar to the eastern meadowlark, which confounds identification.

Habitat: Highest density breeding populations occur in retired croplands and Managed Grasslands where characteristic vegetation includes timothy, brome grass, quack grass, and intermediate wheat grass. Nesting western meadowlarks also use heavily grazed pastures, Hayland, remnant prairie associated with oak savannah, and Old Field Communities. In the Central Plain and Northern Highland, nesting pairs occasionally occupy drier portions of Northern Sedge Meadow.

Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)

Status: Regular migrant and nesting species.

Migration: Fairly common (locally common) migrant in the Western Upland, uncommon and local in the Central Plain, and rare in the Northern Highland. Spring migrants arrive in the Western Upland about 15 April, reaching the Northern Highland by 1 May. Peak spring abundance occurs 1–15 May and nonbreeding birds depart by 20 May. Fall migration begins with dispersal from breeding marshes and the formation of loose flocks in late July. Peak fall abundance occurs 15 August to 1 September and departure by 30 September (latest—9 October 1966, Washington County).

Nesting Season Distribution: Common to locally abundant breeding bird in central St. Croix, Washington, and southern Polk counties. I conducted a census of breeding yellow-headed blackbirds in 1975 and found over 1,000 pairs in central St. Croix County; a 1977 census yielded fewer than 500 pairs. The difference was attributed to persistent drought conditions. Documented breeding records exist for St. Croix, Washington, Polk, and Burnett counties. Breeding Bird Survey data (Table 7) suggest that the largest breeding populations occur in the Western Upland. An isolated breeding population exists at Crex Meadows Wildlife Area, Burnett County. Ellarson (1950) reported two additional colonies in Burnett County in 1948 and 1949 which were still occupied in 1977. Green and Janssen (1975) stated that this species is absent from "much of Pine County."

Habitat: Characteristic nesting species of deep semipermanently and permanently flooded wetlands. Predominant vegetation associated with yellow-headed blackbird nesting habitat includes cattail, river bulrush, hardstem bulrush, and phragmites.

Red-winged Blackbird (*Agelaius phoeniceus*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Abundant migrant throughout the Valley. Spring migrants arrive in late February in the Western Upland, reaching the Northern Highland by 15 March. Peak spring migration occurs 15 March to 10 April. Fall migration begins in mid-July with dispersal from nesting areas and the formation of loose flocks. Numbers gradually build through August reaching peak abundance 10–25 September. During this period, roost flocks ranging from 25,000 to 50,000 individuals can be observed. Most fall migrants have departed by 1 November; however, stragglers remain into early December.

Nesting Season Distribution: Abundant nesting species in the Western Upland and Central Plain, common in the Northern Highland. Breeding Bird Survey data (Table 7) suggest that a very large breeding population exists in the open agricultural areas of the Western Upland and Central Plain. This breeding population diminishes in abundance in the more forested Northern Highland.

Winter: Regular winter resident in the Western Upland, casual elsewhere. Wintering red-winged blackbirds are usually associated with Lowland Deciduous Forest, Shrub Carr, Alder Thicket, natural basin wetlands, farmsteads, and feedlots.

Habitat: Red-winged blackbirds use a variety of wetland and upland sites for nesting. Wetlands include sedge meadows, seasonally, semipermanently, and permanently flooded wetlands dominated by cattail, river bulrush, hardstem bulrush, softstem bulrush, and phragmites. Alder Thicket, Shrub Carr, northern Forest Bordered Wetlands, and Black Spruce–Tamarack Bogs are also important. Upland nesting sites include agricultural fields, Old Field Community, Hayland, Managed Grasslands, and to a lesser extent Northern Hardwood Forest, Southern Deciduous Forest, and Lowland Deciduous Forest. This species is among the most widespread and adaptable breeding birds in the Valley.

Orchard Oriole (*Icterus spurius*)

Status: Casual migrant and nesting species.

Migration: Rare migrant in Pierce, St. Croix, and Washington counties; accidental elsewhere. Migrants arrive 15–20 May, remaining in this region until mid-August. There are two spring records for Polk County: 20 May 1949 and 20 May 1976.

Nesting Season Distribution: Several nesting season records exist in the Western Upland; however, only one confirmed nesting record exists. A nest with eggs was found in Washington County on 15 July 1953 (Herz 1954). S. Sprunt found a singing male near Gordon, Douglas County, on 6 July 1956 (Lound and Lound 1956*b*). Recently, nesting season adults have been regularly observed along the lower Willow River in St. Croix County. Although nest records have not been obtained here, strong evidence of nesting exists.

Habitat: Breeding season orchard orioles are typically associated with open areas in mature Lowland Deciduous Forest.

Northern Oriole (*Icterus galbula*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley, locally abundant adjacent to the St. Croix River in St. Croix, Pierce, and Washington counties. Spring migrants arrive in the Western Upland 1–5 May and peak populations occur 15–20 May. Spring migrants arrive in the Northern Highland by 10 May (earliest—26 April 1957, Burnett County; Lound and Lound 1957*c*), reaching peak populations 20–25 May. Fall migration begins in late July. Peak movement in the Northern Highland occurs 5–20 August and departure is by 10 September. Peak fall migration in the Western Upland occurs 15–30 August and departure is by 15 September (latest—1 December 1971, Washington County).

Nesting Season Distribution: Common nesting species in the Western

Upland and Central Plain, uncommon and local in the Northern Highland. Breeding Bird Survey data (Table 7) suggest that the region of greatest abundance is the Central Plain. Unfortunately, the Hudson BBS route does not traverse large expanses of northern oriole habitat as this species is a common breeding bird in that area. A recent increase in breeding populations is suggested by Jackson's (1943) statement that this species was "nowhere common in the region except at St. Croix Falls," (Polk County). Goddard (1972) reported a density of 20.7 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Habitat: The northern oriole is primarily a species of mature deciduous forest. Also fairly common in ornamental plantings in residential areas. The largest breeding populations occur in mature Northern Hardwood Forest and Lowland Deciduous Forest.

Rusty Blackbird (*Euphagus carolinus*)

Status: Regular migrant and occasional early winter resident.

Migration: Common spring and abundant fall migrant throughout the Valley. Spring migrants arrive in the Western Upland about 10 March and reach the Northern Highland by 25 March. Peak spring populations occur 1-20 April and departure is by 5 May. Fall migrants arrive about 15 September, reaching peak populations 10-25 October. Most have departed from the Northern Highland by 10 November and elsewhere by 1 December.

Winter: Early winter records of this species consist primarily of small flocks associated with lowland forest habitats. Christmas Bird Count data suggest that early winter occurrences are restricted largely to areas adjacent to the lower St. Croix River. However, one record of an individual on the Solon Springs CBC was probably of a late migrant. During January and February, single birds will occasionally frequent feeding stations, including one at a Polk County feeder through 17 February 1959 (Winkler 1959).

Habitat: The rusty blackbird is primarily a species of wetland habitats. Fall concentrations of these birds are typically observed in large Alder Thickets, Shrub Carr, or northern bog habitats. Edges of prairie wetlands are also heavily used, primarily in the Western Upland.

Brewer's Blackbird (*Euphagus cyanocephalus*)

Status: Regular migrant and nesting species.

Migration: Fairly common spring and uncommon fall migrant throughout the Valley. Spring migrants arrive in the Western Upland 10-15 March, reaching the Northern Highland by 1 April. Peak migration occurs 10-30 April and departure from nonbreeding areas by 10 May. Fall migrants arrive in the Western Upland 10-15 August. Peak fall populations occur 25 August to 15 September and departure is by 10 October.

Nesting Season Distribution: Fairly common to locally uncommon nesting species in the Central Plain and Northern Highland. Roberts (1932) described the eastward extension of this species' breeding range from the Red River Valley to east-central Minnesota in the early 1900's. Additional evidence of recent expansion into this region is provided by Jackson (1943) who failed to record this bird in northwestern Wisconsin in 1919.

Winter: Several CBC records of Brewer's blackbird exist for the Suburban St. Paul count. These records include: 4 on 29 December 1962, 4 on 26 December 1964, and 11 on 30 December 1972.

Habitat: Brewer's blackbirds primarily use fencerows, railroad rights-of-way and Old Field habitats. Occasional breeding pairs are encountered in Northern Sedge Meadow, open bog habitats, and in highway rights-of-way.

Common Grackle (*Quiscalus quiscula*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Abundant migrant in the Western Upland and Central Plain, fairly common (locally common) in the Northern Highland. Spring migrants arrive in the Western Upland 20–25 February, reaching the Northern Highland by 30 March. Peak populations occur 20 March to 15 April. Fall migration begins in mid-July with dispersal from breeding areas. Large mixed flocks of common grackles and red-winged blackbirds form in early August, supplemented with Brewer's blackbirds in late August and rusty blackbirds in late September. Peak fall populations occur 10 September to 10 October. Departure from the Northern Highland occurs by 15 October and most birds have departed from the Western Upland by 5 November but stragglers remain to 30 November.

Nesting Season Distribution: Common to locally abundant nesting species in the Western Upland and Central Plain, uncommon to locally common in the Northern Highland. This is one of the most rapidly increasing nesting species in the Valley. Breeding Bird Survey data (Table 7) show a gradual decrease in relative abundance northward from the heavily farmed regions of the Western Upland. In 1919, Jackson (1943) reported that common grackles were "never particularly plentiful, except when they gathered in flocks." The current abundance of this species and the expansion of its breeding range has been fairly recent and may be associated with an expanding human population or changes in agricultural practices.

Winter: Common grackles occasionally overwinter each year in the Western Upland. Individual birds elsewhere may be wintering or late migrants.

Habitat: Common grackles are fairly opportunistic in their selection of nesting habitats and have been recorded in nearly every habitat type. Highest breeding densities are usually associated with Pine Plantations, deciduous woodlots, or ornamental conifer plantings. The increased planting of coniferous trees has enhanced common grackle nesting populations and may be a factor in their expanding and increasing populations.

Brown-headed Cowbird (*Molothrus ater*)

Status: Regular migrant and nesting species, casual early winter resident.

Migration: Abundant spring and uncommon fall migrant throughout the Valley. Spring migrants arrive in the Western Upland 15–20 March and reach the Northern Highland by 10 April. Peak spring populations occur 10–25 April. Fall migration begins with flock formation in late June. A gradual movement away from breeding areas occurs throughout the fall; consequently, no peak population dates can be given. Most migrants have departed by 15 September and stragglers remain through October.

Nesting Season Distribution: Common to locally abundant nesting species throughout the Valley. Breeding Bird Survey data (Table 7) show a large and well-distributed breeding population. Goddard (1972) reported a density of 24.2 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Winter: Several early winter records exist from CBC's in Washington, St. Croix, and Douglas counties. These records include: 1 January 1970 (St. Croix); 1 January 1975, and 3 January 1976 (Washington); and 18 December 1974 (Douglas).

Habitat: Brown-headed cowbirds use virtually all habitats in this region. Largest breeding populations occur in woodland edge situations.

FAMILY THRAUPIDAE: Tanagers

Scarlet Tanager (*Piranga olivacea*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant throughout the Valley. Spring migrants arrive in the Western Upland 1–5 May, reaching the Northern Highland 5–10 May. Peak spring migration through the Valley occurs 10–25 May. Fall migration begins in mid-August. Peak fall migration occurs 25 August to 15 September and departure by 1 October.

Nesting Season Distribution: Fairly common nesting species throughout the Valley. This species is more widespread and probably occurs in greater densities in the Central Plain and Northern Highland. Bernard (1967) considered the scarlet tanager a common summer resident in Douglas County. Jackson (1943) reported this species as common at St. Croix Falls, Polk County, and mentions the observation of mated pairs at that location. Goddard (1972) reported a density of 4.5 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Habitat: Characteristic nesting species of deciduous forest communities. Habitat use by nesting scarlet tanagers varies with geomorphic province. In the Western Upland, this species is most abundant in mature Lowland Deciduous Forest and Southern Deciduous Forest. In the Central Plain and Northern Highland, scarlet tanagers are most abundant in mature Northern Hardwood Forest and in early successional stage aspen forest. Breeding pairs in Jack Pine Barren habitat are normally found in the "scrub" oak savannahs interspersed with jack pine.

Summer Tanager (*Piranga rubra*)

Status: Casual, two records.

Records: One male was observed in Polk County on 18 May 1956 (Lound and Lound 1956*a*). Another male was observed at Grantsburg, Burnett County, on 29 September 1967 (Caldwell 1968).

FAMILY FRINGILLIDAE: Grosbeaks, Finches, Sparrows, and Buntings

Cardinal (*Cardinalis cardinalis*)

Status: Regular permanent resident.

Distribution: Fairly common (locally common) resident of the Western Upland. Uncommon to rare in the Central Plain, and rare and local in the Northern Highland. Movement of the cardinal into this region has been very recent. In 1919 Jackson (1943) failed to report this bird in northwestern Wisconsin. Young et al. (1941) reported that the first records for Burnett and Pierce counties were in 1920. Roberts (1932) reported several mid-1920 records for the Washington County region. By the 1960's Bernard (1967) considered this bird a rare visitor in Douglas County and mentioned records from Solon Springs. M. Link (personal communication) reported that cardinals were regular at Pine City, Pine County, in 1974.

Breeding season records of the cardinal provide excellent documentation of their decreasing population, which is moving northward through the Valley. Breeding Bird Survey data (Table 8) suggest an abrupt decrease in breeding density from a mean of 1.5 per route in the Western Upland to <0.1 per route in the Northern Highland. Goddard (1972) found the mean density of breeding cardinals in the Kinnickinnic River Valley was 16 pairs per 40 ha.

Winter: Common winter resident in the Western Upland. As shown for the breeding season, the abundance of this bird decreases rapidly as it moves northward. On five CBC's in the Valley, the mean number of cardinals recorded per party hour ranged from 3.1 on the Afton CBC to 0 at Solon Springs (Table 4).

Habitat: Primarily a species of deciduous forest edge during the breeding season. Use of Lowland Deciduous Forest and Southern Deciduous Forest is usually restricted to openings and brushy edges. Highway rights-of-way and windbreaks planted around farmsteads are important, as are shrubbery and ornamental plantings in residential areas.

Rose-breasted Grosbeak (*Pheucticus ludovicianus*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants arrive 1–5 May (earliest—30 April 1978, St. Croix County), reaching peak abundance 10–20 May. Fall migration begins in the Northern Highland

25 August. Peak fall migration through the Valley occurs 5–20 Sep-ber. Departure from the Northern Highland occurs 20–25 September elsewhere by 5 October (latest—26 October 1965, Washington County).

ting Season Distribution: Fairly common (locally common) nesting ies in the Western Upland. Population densities apparently increase hward through the Valley. Goddard (1972) reported a density of 31.2 s per 40 ha along the Kinnickinnic River Valley in Pierce County; the -breasted grosbeak was the fifth most abundant breeding bird in that ey. Breeding Bird Survey data (Table 8) suggest that rose-breasted gros-s occur in greatest abundance in the Northern Highland.

itat: The rose-breasted grosbeak is a characteristic breeding species of ure deciduous forest and forest edge. In the Western Upland, this gros-uses Southern Deciduous Forest dominated by mixed stands of white, black, and bur oaks. Also important is mature Lowland Deciduous st characterized by cottonwood, green ash, and American elm along the r river systems. In the Central Plain and Northern Highland, primary is made of mature Northern Hardwood Forest dominated by sugar le, basswood, trembling aspen, and white birch. Residential Habitats, arily ornamental shade trees, are also used for nesting.

le 8. *Mean number of grosbeaks, finches, towhees, and sparrows orded on western Wisconsin Breeding Bird Survey transects, 1966–78.*

	Western Upland	Central Plain		Northern Highland	
cies	Hudson	Dresser	Loraine	Union	Minong
linal	1.5	0.6	0.0	<0.1	<0.1
-breasted grosbeak	6.0	12.2	18.1	15.0	19.6
go bunting	7.4	8.7	23.3	18.5	18.6
cissel	12.1	6.4	5.4	0.0	0.0
rican goldfinch	4.7	9.1	20.6	6.0	5.9
le finch	0.0	0.0	0.0	1.0	3.3
siskin	0.0	0.0	<0.1	<0.1	0.2
us-sided towhee	0.2	0.2	0.6	21.7	15.8
nnah sparrow	17.3	14.1	26.3	0.0	0.3
shopper sparrow	9.6	5.7	6.7	0.7	0.0
low's sparrow	1.2	1.1	0.5	0.0	0.0
er sparrow	18.9	15.3	13.7	6.5	8.6
-eyed junco	0.0	0.0	0.0	0.0	0.6
ping sparrow	1.6	6.3	10.9	21.2	24.2
-colored sparrow	4.4	3.0	2.7	7.2	14.9
sparrow	7.0	3.2	2.2	10.2	1.9
e-throated sparrow	0.0	0.0	<0.1	0.0	3.5
ln's sparrow	0.0	0.0	0.0	0.0	<0.1
np sparrow	0.0	0.2	0.9	0.2	1.1
sparrow	12.9	24.4	32.6	3.5	24.0

Black-headed Grosbeak (*Pheucticus melanocephalus*)

Status: Casual spring migrant.

Records: This western grosbeak has been recorded in the Valley on four oc sions. The first record was a male on 27 May 1970 in Washington Coun (Huber 1974*a*). A female was observed in Washington County 11 May 1 June 1974, and a male was noted in the same location on 13 May 19 (Savaloja 1974). I observed a singing male in Glen Park at River Falls, Pie County, on 25 May 1979 (Eckert 1979).

Indigo Bunting (*Passerina cyanea*)

Status: Regular migrant and nesting species.

Migration: Common migrant in the Western Upland and Central Plain, u common (locally common) in the Northern Highland. Spring migrants arri in the Western Upland 1-5 May (earliest—26 April 1976, Pierce County) a reach the Northern Highland 5-10 May. Peak spring migration through t Valley occurs 15-30 May. Fall migration begins about 10-15 August. Pe fall migration occurs 1-15 September and departure 20 September to 5 O tober.

Nesting Season Distribution: Common and well-distributed nesting speci in the Western Upland and Central Plain. Fairly common in the Northe Highland, except in regions of extensive coniferous forest. Jackson (19 considered the indigo bunting an uncommon nesting bird in the Northe Highland in 1919. In the Western Upland, Goddard (1972) found the indi bunting was the 12th most numerous breeding bird ($\bar{X} = 21.8$ pairs p 40 ha) along the Kinnickinnic River Valley, Pierce County. Breeding Bi Survey data (Table 8) suggest that lowest populations occur in the heav farmed regions of the Central Plain but increase northward into the Nort ern Highland.

Habitat: The indigo bunting is a characteristic breeding bird of shrub "edge" habitat types. In the Central Plain and Northern Highland, Dec uous Clear Cuts under 10 years old receive heavy use by nesting indigo bu ings. Important vegetation associated with their breeding habitat includ trembling aspen, box elder, basswood, choke cherry, hazelnut, and prick ash.

Dickcissel (*Spiza americana*)

Status: Regular migrant and nesting species.

Migration: Common migrant in the Western Upland and Central Plain, ra and local in the Northern Highland. Populations of this bird experience t mendous variations between years and they appear to be cyclic. In adjace years, dickcissels can vary from among the most numerous migrants grassland habitats to virtually absent. Spring migrants arrive in t Western Upland and Central Plain 20-30 May and are widespre

10 June. During most years, this bird is most numerous during the first days of June. Singing ceases about 1 August and birds become difficult find after that date. There is no discernible peak in fall migration, and st have departed by 25 August (latest—16 September 1974, Polk unty).

sting Season Distribution: Fairly common although highly irregular sting species in the Western Upland and Central Plain. There are no own nest records for Douglas or Pine counties, although Green and Jans- n (1975) stated that the breeding range in Minnesota "usually extended ly to southern Pine County." Jackson (1943) did not record this species in rthwestern Wisconsin during 1919.

During 1975, the dickcissel was virtually absent from St. Croix and Wash- ton counties during the nesting season. In 1976, I recorded a density of 4 pairs per 40 ha on Managed Grassland tracts in St. Croix and Polk unties. Breeding Bird Survey data (Table 8) provide another indication of rapid decrease in abundance moving northward from the Western land to Northern Highland.

bitat: Characteristic breeding bird of retired agricultural fields that have ome overgrown with a rank growth of vegetation. Also an important eding bird of alfalfa fields and of Managed Grasslands that are main- ned by various State and Federal wildlife agencies for duck nesting cover.

ening Grosbeak (*Hesperiphona vespertina*)

tus: Regular migrant and winter resident, casual summer visitor, and sible nesting species.

gration: Common yet erratic fall and spring migrant in the Western land and Central Plain. Usually a common to abundant migrant in the thern Highland. Migration periods appear to depend upon the abun- ce of a food source in the northern breeding areas. The first fall migrants ally arrive in the Northern Highland 1–15 October and reach the stern Upland about 15 November, except during invasion years, when y have been recorded in mid-October (15 October 1959, Polk County). k fall migration varies with the year, however, usually occurring 15 No- ber to 15 December. Peak spring migration usually occurs during rch. During non-invasion years, peak spring migration occurs 25 March May. The largest late flock on record (600) was observed at Webster rnett County) on 25 April 1950. Departure also apparently varies with year. There are several Polk County departure records that range from ay (1954) to 17 May (1952). Latest dates from nonsummering areas ude 28 May 1962, Polk County and 30 May 1972, Burnett County.

ting Season Distribution: Casual summer resident in the Northern High- l. There are no confirmed nest records for the Valley, although a few s may remain to nest after invasion years. Evening grosbeaks were re- led during the 1972 summer in Pine County (Green and Baumhoffer 2). S. D. Robbins recorded evening grosbeaks along the route of the ong BBS during mid-June from 1965 to 1977. During June 1974 I observed three male evening grosbeaks in Sec. 14, T. 43 N., R. 15 W., Dougl, County, but no evidence of nesting.

Winter: Usually a common to locally abundant winter resident in the Nor-ern Highland. Uncommon to rare (except during invasion years) winter re-dent in the Central Plain and Western Upland. The highest mean numbers f evening grosbeaks per party hour on CBC are 8.3 at Grantsburg and 3.3 t Solon Springs (Table 4), both in the Northern Highland. The highest cout of individuals on CBC's was 739 recorded on the 1974 Grantsburg Cou Considerable variation also exists in yearly totals, which is indicative of t cyclic influxes of this species.

Habitat: Migrant evening grosbeaks use both deciduous and conifers habitats. Box elder and maple trees that retain their fruits are preferd during migration. Most winter records are obtained from the vicinity of fe-ing stations, both in rural and urban areas. My records of this bird durig the breeding season were obtained from an extensive stand of black sprue adjacent to a stream. This vegetation type appears to be preferred in te northern breeding areas.

Purple Finch (*Carpodacus purpureus*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Common migrant in the Western Upland and Central Plain, oc-sionally abundant in the Northern Highland. Fall migration begins in e Northern Highland about 25 August and the first birds arrive in the Wt-ern Upland 15–25 September. Peak fall migration occurs 1 October o 15 November and departure from nonwintering areas by 1 December (t-est—18 December 1979, Douglas County). Spring migrants arrive in e Northern Highland about 15 March. Peak spring migration occurs 25 Mah to 15 April and departure by 1 May (latest—10 May 1970 and 17 May 1, Washington County).

Nesting Season Distribution: Fairly common nesting species in the No-ern Highland. Confirmed nest records exist for Burnett, Polk, and Dougs counties. Green and Janssen (1975) cited an inferred breeding record for Fe County. Breeding Bird Survey data (Table 8) suggest that nesting is e-stricted to the Northern Highland. The most southerly nest record tha I have obtained was a female incubating four eggs on 26 May 1974 near Cn Falls, Polk County (Sec. 11, T. 35 N., R. 15 W.). Jackson (1943) observe a mated pair at St. Croix Falls, Polk County, on 25 May 1919.

Winter: Common (locally abundant) winter resident in the Western Upla d. Becomes progressively more scarce in the Central Plain and is virtuy absent from the Northern Highland. Christmas Bird Count data (Tabl 4) demonstrate sharp declines in winter abundance moving northward fn the lower St. Croix River. On 1 January 1978, 294 were recorded on he Afton CBC. On 16 February 1979, I banded 105 at a feeding statio n Hudson, St. Croix County.

Habitat: During the nesting season, the purple finch is a characteri ic

ecies of cool, moist, Lowland Coniferous Forest. Principal vegetation asso-
ated with breeding habitat includes black spruce, tamarack, yellow birch,
d black ash. All purple finch nests that I have observed were associated
th this vegetation type. During migration, purple finches were also found
deciduous habitats, primarily those having heavily seeded box elder. Win-
ing birds are usually found in black spruce habitat or near feeding
ations in residential areas.

ne Grosbeak (*Pinicola enucleator*)

atus: Regular migrant and winter resident.

gration: Uncommon fall migrant (occasionally common) in the Northern
ghland, rare and irregular fall migrant (occasionally fairly common) in the
ntral Plain and Western Upland. Less common in all regions during
ing migration, except after invasions. On 23 November 1946 pine gros-
aks were already considered "numerous" at Grantsburg, Burnett County.
ll migrants arrive in the Northern Highland 25 October to 15 November.
ak fall migration occurs 15 November to 15 December. Spring migration
gins with a gradual northward exodus in late February. Peak spring
gration occurs 1–15 March and departure by 1 April (latest—8 May 1974,
lk County).

nter: Irregular winter resident except for the Northern Highland where
ntering pine grosbeaks are observed each year. Winter populations of this
d are considered cyclic. The largest number recorded in the Valley was
on the Solon Springs CBC 17 December 1970. Christmas Bird Count
a (Table 4) provide supportive evidence of their relative abundance in the
ious regions of the Valley.

bitat: Generally restricted to extensive stands of Lowland Coniferous
est and Jack Pine Barrens. During invasion years, pine grosbeaks use
land Deciduous Forest, especially if box elder and maple or sumac trees
heavily laden with seeds.

ay-crowned Rosy Finch (*Leucosticte tephrocotis*)

tus: Accidental, one record.

ord: Ludwig (1974) described the observation of a single gray-crowned
y finch in Pine County 27 March to 6 April 1974. This was the third
ord of that species in Minnesota.

ary Redpoll (*Carduelis hornemanni*)

tus: Irregular migrant and winter resident.

ration: During invasion years, a rare migrant in the Northern Highland
Central Plain, casual in the Western Upland. There are too few spring
ords to establish patterns. Fall migrants usually arrive with the first
e flocks of common redpolls in late November (earliest—3 November

1968, Burnett County; 21 November 1950, Polk County). During sprin
migration, hoary redpolls are observed with common redpoll flocks. Mo
observations occur in February. Late dates include 4 April 1966, St. Cro
County; 6 April 1969, Chisago County; and 12 April 1974, Washingto
County.

Winter: Rare and irregular winter resident throughout the Valley. Mo
winter records consist of observations during the CBC periods, usual
15 December to 2 January. The largest number observed (six) was record
on the Suburban St. Paul CBC 29 December 1973. Considerable debate ha
been generated concerning the taxonomic status of this bird and the abili
of observers to make accurate identification. The most reliable and undoub
edly correct observations are of banded birds. One individual was banded
Chisago County on 1 March 1970. During the winter finch invasion
1977–78, I banded two hoary redpolls at a feeding station in Hudson, S
Croix County, on 15 February 1978 and 8 March 1978. The latter bird wa
photographed extensively and copies were deposited with the Wiscons
Society for Ornithology.

Habitat: Regularly observed with flocks of common redpoll in weedy fiel
and highway rights-of-way.

Common Redpoll (*Carduelis flammea*)

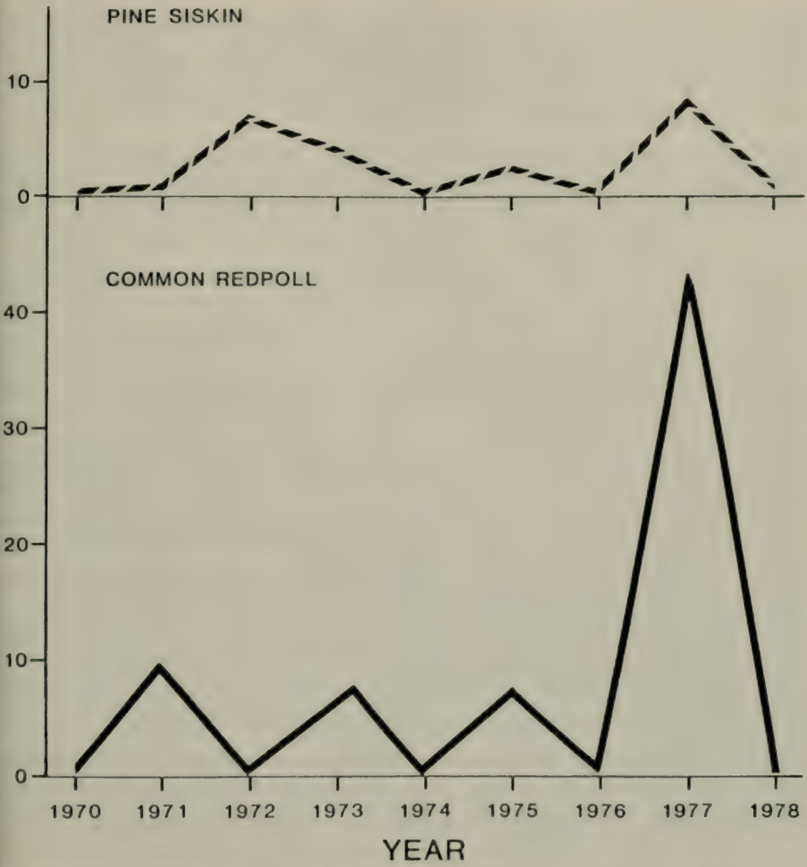
Status: Regular migrant and winter resident.

Migration: Abundant migrant throughout the Valley during periodic inv
sion years, uncommon to rare migrant during other years. Fall migran
arrive 25 October to 10 November (earliest—12 October 1974, Burne
County). Peak fall migration occurs 15 November to 15 December. Pe
spring migration occurs 1–25 March; birds depart from the Central Pla
1–10 April and the Northern Highland by 30 April (latest—30 May 197
Burnett County).

Winter: Usually an uncommon winter resident except during invasion yea
when this species becomes one of the most abundant wintering birds. Chri
mas Bird Count data (Table 4) suggest that the wintering population
fairly well distributed throughout the Valley. The extremely high me
number of common redpolls per party hour on the Solon Springs CBC
skewed upward by a large count during 1977.

The normal 2-year invasion cycle of this bird is shown by comparing t
mean number of redpolls per party hour on CBC's throughout the Vall
(Fig. 6). Beginning with the 1970 count year, the winter common redp
population fits a perfect alternate year invasion schedule. Results from t
1977–78 CBC season are considerably higher than other years because t
movement of birds that year was one of the largest recorded. The tw
largest counts on record in the Valley are from the Solon Springs CB
(2,222) and Suburban St. Paul CBC (4,615). The 4,615 is the largest numb
ever recorded in North America (Monroe 1978).

Habitat: Agricultural fields, retired cropland that has become heavily ov



g. 6. Patterns of winter abundance of common redpolls and pine siskins in the St. Croix River Valley (data from Christmas Bird Counts).

own with various weeds, highway rights-of-way, and mixed decid-us-coniferous forest in northern regions.

ne Siskin (*Carduelis pinus*)

atus: Regular migrant, nesting species, and winter resident.

igration: Fairly common (occasionally abundant) migrant throughout the lley. Fall migrants arrive in the Central Plain and Western Upland 15- 25 ptember. Peak fall migration occurs 10-30 October and departure by November. The number of fall migrants is highly dependent on the inten-y of the migration during a given year. Typical of other winter finches, ak movements usually occur during invasion years. Migrants have ually departed the Northern Highland by 1 January, except during years very high populations when large numbers winter throughout the Valley.

Spring migration begins in late March with a gradual exodus from th southern wintering areas. Spring migration is usually more diffuse than fa and the period of peak movement occurs 10 April to 15 May. Departur from the southern areas occurs 20–30 May.

Nesting Season Distribution: Uncommon nesting species in the Norther Highland. Jackson (1943) reported that pine siskins were "not uncommon at Solon Springs (Douglas County) from 26 July to 6 August 1919. He doe not provide any evidence of nests or young. Larson (1970) reported pin siskins at Taylor's Falls, Chisago County, through the summer of 1969 an until 10 August 1970. No nests or young were reported. On 11 May 1978, banded a female pine siskin at Hudson, St. Croix County, that possessed well-defined brood patch. Although no nests or young were observed, pin siskins remained in the area throughout the summer of 1978 and probabl nested.

Winter: Fairly common resident in the Western Upland and Central Plair Uncommon to rare during midwinter in the Northern Highland excep during invasion years. Christmas Bird Count data (Table 4) suggest a rapi decline in relative abundance of this species moving northward from th lower St. Croix River Valley. Although not as predictably cyclic as th common redpoll, the pine siskin follows a pattern of abundance 1 year, fo lowed by low numbers for 2–3 years afterward (Fig. 6). Highest daily count of individuals include 856 on 1 January 1974 (Afton CBC) and 793 on 2 Jar uary 1978 (Suburban St. Paul CBC). On 10 February 1961 S. D. Robbins ob served over 3,000 pine siskins at Clam Lake, Burnett County.

Habitat: Restricted primarily to coniferous forest during the nesting seasor Wintering birds use a variety of coniferous and deciduous habitats. Thi species makes extensive use of feeding stations in residential areas.

American Goldfinch (*Carduelis tristis*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Common migrant throughout the Valley. Spring migrants arriv in the Western Upland 15–30 March, reaching peak abundance 15–30 Apri Migrants arrive in the Northern Highland 10–15 April, reaching peak num bers about 1 May. Fall migration begins in mid-August and peak popu lations occur 15 September to 15 October. Departure from the norther areas occurs by 15 November.

Nesting Season Distribution: Fairly common and well-distributed nestin species throughout the Valley. Jackson (1943) considered the America goldfinch one of the most generally distributed nesting species in nort western Wisconsin. Breeding Bird Survey data (Table 8) support Jackson' statement. This bird was the fourth most abundant breeding species (33. pairs per 40 ha) in the Kinnickinnic River Valley, Pierce County (Goddar 1972).

Winter: Fairly common to locally common winter resident in the Wester Upland and Central Plain. Rare and irregular winter resident of the North n Highland, particularly after mid-January. Christmas Bird Count data able 4) suggest a gradual decrease in relative abundance progressing rthward. Highest daily counts include 559 on 30 December 1978 (Sub-ban St. Paul CBC) and 545 on 1 January 1975 (Afton CBC).

abitat: Typically a nesting species of edge situations including stream nks, brushy edges of woods, highway rights-of-way, and ornamental rubbery in urban areas.

ed Crossbill (*Loxia curvirostra*)

atus: Regular migrant and winter resident, irregular summer resident, d nesting species.

igration: Irregular migrant throughout the Valley. During periods of peak currence, red crossbills are uncommon except in the Northern Highland here they become locally common. Because of their erratic movements, it is fficult to determine their migration periods, particularly in the Northern ighland. The normal period of occurrence in the Western Upland and Cen-al Plain is 1 October to 1 April; stragglers remain until mid-May.

esting Season Distribution: Rare and irregular during the nesting season, imarily in the Northern Highland. Jackson (1943) mentioned the observa-n of a "flock" at Solon Springs, Douglas County, on 8 August 1919. ckson (1970) provided the only confirmed nesting record for the Valley en he observed several adults feeding young at Stillwater, Washington unty, during May 1970. Larson (1970) found red crossbills near Taylor's lls, Chisago County, until 5 June 1970 but no evidence of nesting.

inter: Uncommon and irregular winter resident, usually observed in the orthern Highland. Although this species is dependent on the pinecone op, population irruptions of red crossbill are not predictable.

abitat: Breeding season records are typically associated with Lowland niferous Forest or Northern Hardwood Forest intermixed with coniferous ees.

hite-winged Crossbill (*Loxia leucoptera*)

atus: Regular migrant and winter resident, erratic summer resident.

igration: Uncommon to rare migrant; most observations are confined to e Northern Highland. Similar in distribution to the red crossbill in occur-nce and distribution. During years of peak influxes, white-winged cross-lls are locally common to abundant, primarily in the Northern Highland d Central Plain. The normal period of occurrence ranges from 15 October 15 March.

esting Season Distribution: There are no confirmed nest records of this ossbill in the Valley. S. D. Robbins recorded single birds along the route of e Minong BBS, Douglas County, on 11 June 1969 and 21 June 1977. Rob-ns observed two white-winged crossbills along the route of the Union BBS, rnett County, on 22 June 1977.

Winter: Uncommon to locally common winter resident in the Northern Highland. Rare to uncommon winter resident elsewhere. During the winter of 1977–78, the movement of this bird into the Valley was among the largest on record. Exceptionally large flocks (200 individuals) were noted, primarily north of St. Croix Falls. These large numbers remained through mid-December. After that time, the number of individuals decreased considerably.

Habitat: This species primarily uses extensive stands of Lowland Coniferous Forest where white spruce is the predominant tree species. Also occasionally observed in mixed coniferous–deciduous forest and Jack Pine Barren.

Green-tailed Towhee (*Pipilo chlorura*)

Status: Accidental, one record.

Record: Garber (1965) reported the observation of one bird at Prescott Pierce County, on 10 May 1964.

Rufous-sided Towhee (*Pipilo erythrophthalmus*)

Status: Regular migrant and nesting species.

Migration: Uncommon migrant throughout the Valley, common in th Northern Highland. Spring migrants arrive in the Western Uplan 25–30 April and the Northern Highland 1–5 May. Peak migration occur 5–15 May. Peak fall migration occurs 10–25 September and departure b 15 October (latest—8 December 1971, Washington County).

Nesting Season Distribution: Uncommon nesting species throughout th Valley. Jackson (1943) reported that rufous-sided towhees were common a Solon Springs, Douglas County, 28 July to 6 August 1919. Goddard (1972 reported a density of 19.3 pairs per 40 ha in the Kinnickinnic River Valley Pierce County. Breeding Bird Survey data (Table 8) suggest that the rufous sided towhee occurs in relatively low numbers in the Western Upland an Central Plain and is common in the Northern Highland.

Habitat: Primarily a species of edge situations. Typical breeding habitat i cludes semi-open stands of Northern Hardwood Forest (Western Upland Typical vegetation of these habitats includes second-growth bur oak, tremb ling aspen, sugar maple, green ash, and basswood. In the Northern Hig land, this species becomes particularly numerous in mixed stands of jac pine and oak.

Savannah Sparrow (*Passerculus sandwichensis*)

Status: Regular migrant and nesting species.

Migration: Common spring and fall migrant throughout the Valley. Sprin migrants arrive in the Western Upland 10–15 April and the Northern Hig land about 20 April (earliest—30 March 1967, Burnett County). Peak sprin migration through the Valley occurs 20 April to 10 May. Peak fall migratio ccurs 15–30 September and departure by 15 October (latest—25 October 967, St. Croix County).

esting Season Distribution: Fairly common nesting species in the Western pland and Central Plain, uncommon and more localized in the Northern ighland. Breeding Bird Survey data (Table 8) suggest that in the Western pland and Central Plain the savannah sparrow is among the three most ommon nesting sparrows. However, this abundance decreases rapidly oving northward into the heavily forested Northern Highland.

abitat: Characteristic breeding species of various grassland communities. mportant among these are retired cropland, Old Field Community, highay rights-of-way, Managed Grasslands maintained for duck production, nd lightly to moderately grazed tame pasture that is predominantly imothy or Kentucky bluegrass. Also important, although to a lesser degree, re alfalfa and oat fields. In Northern regions, savannah sparrows make xtensive use of wet meadow habitats, primarily Northern Sedge Meadow.

rasshopper Sparrow (*Ammodramus savannarum*)

tatus: Regular migrant and nesting species.

igration: Fairly common migrant throughout the Western Upland and entral Plain, uncommon to rare and localized in the Northern Highland. pring migrants arrive in the Western Upland 25 April to 1 May and the orthern Highland about 5 May. Peak spring migration is difficult to deterine, although it is widely distributed 5–15 May. During the fall, grassopper sparrows are rarely encountered after the song period ceases about August, but they are probably present until mid-September.

esting Season Distribution: Fairly common nesting species in the Western pland and Central Plain, rare and local in the Northern Highland. Jackson 1943) did not record this sparrow during the 1919 nesting season in northestern Wisconsin. Breeding Bird Survey data (Table 8) suggest that the reeding populations in the Western Upland and Central Plain occur in early equal abundance, becoming much smaller in the Northern Highland.

abitat: Primarily a nesting species of various grassland communities. Imortant among these are retired croplands, unmowed highway rights-ofay, Managed Grasslands maintained for duck production, and lightly razed tame pasture that is predominantly Kentucky bluegrass or timothy. lso important, although to lesser degrees, are alfalfa and oat fields. Occaional use is made of the drier portions of Shrub Carr wetlands and Northern edge Meadow.

aird's Sparrow (*Ammodramus bairdii*)

tatus: Hypothetical, two records.

ecords: One bird was observed at Crex Meadows, Burnett County, on 2 May 1957 (Stone 1957). Goddard (1976) reported a single bird, also at rex Meadows, on 2 May 1975.

Le Conte's Sparrow (*Ammospiza leconteii*)

Status: Regular migrant and summer resident.

Migration: Rare migrant throughout the Valley, fairly common at Crex Meadows, Burnett County. Migrants arrive in the Western Upland about 5 May (earliest—24 April 1976, St. Croix County). LeConte's sparrow is most regularly observed 10–25 May. Fall migration records range from 3 September to 4 October (latest—11 October 1963, Burnett County).

Nesting Season Distribution: Green and Janssen (1975) show the breeding range of LeConte's sparrow extending throughout the three Minnesota counties. Although summer records exist for Burnett, Polk, and St. Croix counties, young have been observed only at Crex Meadows. The most southerly breeding season records include single birds near New Richmond, St. Croix County, on 15 June to 2 July 1964, and 16 June 1966 (Robbins 1969*b*), and a singing male near Roberts, St. Croix County, on 27 June 1977 (Sec. 32 T. 30 N., R. 18 W.). Robbins (1969*b*) also recorded LeConte's sparrow in two Polk County locations (T. 35 N., R. 16 W.) on 15 June 1968. Two late May records from Pine County (23 May 1970 and 29 May 1971) were probably of birds on breeding territory.

The best known and probably most extensively explored summer area for LeConte's sparrow is the Crex Meadows Wildlife Area, Burnett County Southern (1962) found several LeConte's sparrows in the marshes at Crex Meadows between 23 June and 2 July 1959. Subsequent to his original observations, other birders have investigated this area extensively and have found that this species occurs commonly in proper habitat. On 10 June 1977 I recorded 11 singing males in one marsh at Crex Meadows (Sec. 15 T. 39 N., R. 18 W.). Frequency of occurrence and observations of apparent territorial behavior indicate that LeConte's sparrow still nests at Crex Meadows, although no nests have been obesrved recently. Intensive investigation of similar areas in Pine and southern Douglas counties should revea additional breeding areas.

Habitat: Typical breeding habitat at Crex Meadows includes extensive stands of Northern Sedge Meadow characterized by manna grass, water sedge, bluejoint grass, rattlesnake grass, and dark-green bulrush. Breeding season records of this sparrow away from Crex Meadows have consisted of birds in drier upland grasses, primarily timothy, bromegrass, and Kentucky bluegrass.

Henslow's Sparrow (*Ammodramus henslowii*)

Status: Regular migrant and nesting species.

Migration: Rare migrant in the Western Upland and Central Plain. Spring migrants arrive in the Western Upland 25 April to 1 May. There is very little movement that could be considered peak spring migration. Most of the birds observed in the Valley appear to be on or near a nesting territory. A Henslow's sparrow was observed at Crex Meadows, Burnett County, on 15 May 1954. This is the only record for the Northern Highland. Fall migra on is similar to spring in that no well-defined movements have been oberved. Most fall observations have been made during August (latest—2 September 1977, St. Croix County).

esting Season Distribution: Rare and local nesting species, restricted priarily to the Western Upland and Central Plain (Table 8). The secretive beavior of Henslow's sparrow and its short and nondescript song make this ird one of the most difficult breeding birds in the Valley to observe.

abitat: Restricted during the breeding season to several grassland comunities. Primary use is made of retired agricultural fields that have deeloped a rank growth of vegetation, primarily timothy and various forbs. anaged Grasslands maintained for duck production provide important esting habitat, especially when vegetation height exceeds 0.5 m. Occaonal use is made of alfalfa fields and tame pastures or thick grassland egetation associated with the periphery of seasonally and semipermanently ooded wetlands.

harp-tailed Sparrow (*Ammospiza caudacuta*)

tatus: Casual migrant and summer resident.

igration: Three spring and one fall migration records exist for the Valley cluding 19 May 1964, St. Croix County; 8 May 1974, Pierce County aanes and Goddard 1976); and 23 May 1976, Burnett County (Crex eadows). One bird was observed in St. Croix County on 18 August 1977. ecause of the secretive habits of this species, and its extremely highitched song, the sharp-tailed sparrow is probably more common than cords indicate.

esting Season Distribution: The sharp-tailed sparrow has been recorded at rex Meadows, Burnett County, on at least five occasions during the esting season. The first record was of one singing male on 21–22 July 1969. n 31 July and 1 August 1970, one singing male was recorded in the same ea. It was not until 13 August 1975 that T. C. Baptist again recorded this arrow in the same marsh. Tessen (1978) reported observing at least three nging males on 28 and 29 May 1977. Later, on 10 June 1977, I recorded e singing male at the same location. All Crex Meadows observations ring the breeding season were made in a large sedge meadow in Sec. 15, T. N., R. 18 W. Because of the territorial behavior exhibited by these birds, arp-tailed sparrows can be considered a probable breeding species at Crex eadows.

abitat: The area that sharp-tailed sparrows occupy at Crex Meadows is an tensive Northern Sedge Meadow that is characterized by manna grass, uejoint grass, and water sedge. Although habitat similarities exist beveen sharp-tailed and LeConte's sparrow at Crex Meadows, apparently arp-tailed sparrows choose moister areas in the meadow.

esper Sparrow (*Pooecetes gramineus*)

tatus: Regular migrant and nesting species.

Migration: Common spring and fall migrant in the Western Upland and Central Plain, uncommon and more local in the Northern Highland. Spring migrants arrive in the Western Upland 5–10 April (earliest—25 March 1963, St. Croix County) and the Northern Highland 10–15 April. Peak spring migration through the Valley occurs 15 April to 1 May. Peak fall migration occurs 1–20 September and departure by 15 October.

Nesting Season Distribution: Common nesting species in the Western Upland and Central Plain, uncommon in the Northern Highland. Erickson (1937), however, considered it abundant in Pine County. Breeding Bird Survey data (Table 8) suggest that the vesper sparrow is the second most abundant nesting sparrow in the Valley. Jackson (1943) reported that the vesper sparrow was a common breeding bird throughout most of northwestern Wisconsin in 1919.

Habitat: Characteristic nesting species of edge situations including fencerows adjoining agricultural fields and the border of retired cropland with deciduous forest. Brushy highway rights-of-way and Old Field Communities are regularly used in the Western Upland and Central Plain. Breeding vesper sparrows in northern regions occur in open areas, brushy fields, or occasionally in openings in Jack Pine Barrens.

Lark Sparrow (*Chondestes grammacus*)

Status: Regular migrant and summer resident.

Migration: Rare spring and fall migrant in the Western Upland and Central Plain, absent from the Northern Highland except in the region near Grantsburg, Burnett County. Spring migration dates occur during a narrow range from 10–25 May. Fall migration dates range from 1–15 September.

Nesting Season Distribution: The only evidence of possible breeding in the Valley is available from the Union BBS transect in Burnett County. S. D. Robbins found a small breeding "colony" of lark sparrows near Grantsburg on 26 June 1975. Since then, up to five singing males have been recorded in that location each year, but no nests of young have yet been found. Green and Janssen (1975) showed that the breeding range of this sparrow in Minnesota includes Chisago, Washington, and southern Pine counties. S. D. Robbins (personal communication) observed lark sparrows near Cushing, Polk County, on 22 June 1977 and near North Hudson, St. Croix County, on 8 July 1965. During June 1977 I observed a group of five lark sparrows in St. Croix County (Sec. 22, T. 30 N., R. 18 W.). The appearance of two of these birds suggested that they were young of the year. Kemper (1973) considered this species rare in Chippewa and Eau Claire counties, 120 km east of the St. Croix County location.

Habitat: Lark sparrows at the Burnett County location use an open area in mixed bur oak–jack pine. The St. Croix County location was characterized by the brushy edge of a Managed Grassland.

ark-eyed Junco (*Junco hyemalis*)

tatus: Regular migrant, nesting species, and winter resident.

igration: Abundant migrant throughout the Valley. Determination of rival of spring migrants in the Western Upland and Central Plain is con- unded by wintering birds. The first noticeable influxes occur 1–15 March. irst spring migrants arrive in the Northern Highland 15–30 March. Peak pring migration through the Valley occurs 30 March to 15 April and de- arture from nonbreeding areas by 15 May. Fall migration begins in the orthern Highland during early September. First migrants arrive in the estern Upland 15–25 September. Peak fall migration occurs during Oc- ber and most nonwintering birds have departed by 1 December.

esting Season Distribution: Rare nesting species, restricted to the North- n Highland. Roberts (1932) reported young being fed in Pine County uring late June 1918, the first breeding record for the Valley. Two young ark-eyed juncos were observed in Chisago County on 16 June 1950 (Warner 951). Breeding Bird Survey data (Table 8) also suggest that the breeding opulation of this species is rather limited in the Valley. An adult that I ob- rved near Deer Park, St. Croix County, on 23 June 1976 was extralimital nd probably an extremely late migrant.

inter: Common (locally abundant) winter resident along the lower St. roix River in Pierce, St. Croix, and southern Washington counties. Rare nd local in the Central Plain, occasional in the Northern Highland. Christ- as Bird Count data (Table 4) show the rapid decrease in relative abundance f this species moving north through the Valley during the winter. Dark- yed juncos are well known for their attachment to the numerous winter eding stations in residential areas.

abitat: Primarily a species of drier upland habitats including Jack Pine arrens and mixed Northern Hardwood Forest. Roberts (1932) mentioned hat nesting dark-eyed juncos are also associated with "spruce and cedar wamps of the lowlands" in Pine County. Wintering dark-eyed juncos make xtensive use of edge habitats, particularly hedgerows, and to a lesser ex- ent several deciduous forest types, primarily Southern Deciduous Forest nd Lowland Deciduous Forest.

ree Sparrow (*Spizella arborea*)

tatus: Regular migrant and winter resident.

igration: Abundant migrant throughout the Valley. Fall migrants arrive the Northern Highland 5–10 October and in the Western Upland 0–15 October. Peak fall migration occurs 25 October to 25 November and eparture of most nonwintering birds occurs by 30 November. Spring igrants arrive in the Northern Highland 1–10 April. Peak spring migra- ion throughout the Valley occurs 10–20 April and departure by 30 April; ccasional stragglers linger through 15 May.

Vinter: Fairly common (locally common) winter resident in the Western Upland, rare and local in the Central Plain. Christmas Bird Count data (Table 4) suggest that highest winter populations occur in areas directly adjacent to the lower St. Croix River. Populations decrease rapidly in areas northward from the Central Plain. The tree sparrow has not been recorded on the Solon Springs CBC, Douglas County.

Habitat: During migration, the tree sparrow uses a variety of open habitats including agricultural fields, retired cropland, and wetland edges. During midwinter, extensive use is made of retired croplands that support dense weedy patches. Grassy openings in Southern Deciduous Forest and occasional remnant prairie patches occurring along the river bluffs are also important.

Chipping Sparrow (*Spizella passerina*)

Status: Regular migrant and nesting species.

Migration: Common migrant throughout the Valley. Spring migrants arrive in the Western Upland 10–15 April (earliest—3 April 1971, Washington County) and reach the Northern Highland about 15–20 April. Peak spring migration through the Valley occurs 1–15 May. Peak fall migration occurs 10 September to 1 October and departure by 15 October (latest—3 November 1963, St. Croix County).

Nesting Season Distribution: Common nesting species throughout the Valley. Breeding Bird Survey data (Table 8) suggest that the largest breeding population occurs in the northern regions of the Central Plain and throughout the Northern Highland. Jackson (1943) reported that chipping sparrows were common nesting birds throughout northwestern Wisconsin. Goddard (1972) reported a density of 11.1 pairs per 40 ha in the Kinnickinnic River Valley, Pierce County.

Habitat: Primarily a nesting species of various coniferous habitats including Lowland Coniferous Forest, Black Spruce–Tamarack Bogs, and Jack Pine Barrens. In residential areas, this sparrow is common in ornamental shrubs. Breeding pairs are occasionally encountered in brushy margins between Lowland Deciduous Forest and open fields. Jackson (1943) described a chipping sparrow nest at St. Croix Falls that was 6.4 m above ground in a large white pine.

Clay-colored Sparrow (*Spizella pallida*)

Status: Regular migrant and nesting species.

Migration: Fairly common migrant throughout the Valley. Spring migrants arrive in the Western Upland 25 April to 1 May and the Northern Highland 5–10 May (earliest—29 April 1961, Burnett County). Peak spring migration through the Valley occurs 10–20 May. Peak fall migration occurs 20 August to 5 September in the Northern Highland and 10–25 September elsewhere. Departure from the Northern Highland occurs about 20 September (latest—16 October 1963, Burnett County) and the Western Upland 1–15 October.

Nesting Season Distribution: Fairly common and local nesting species in all regions, probably most abundant in the Northern Highland (Table 8). Jackson (1943) reported that the clay-colored sparrow was a common nesting species at Danbury (Burnett County) and Solon Springs (Douglas County) in 1919. Clay-colored sparrows apparently become semicolonial where habitat is favorable.

Habitat: Primarily a species of edge situations including brushy fields. This species becomes numerous in recently burned areas or where there are relatively young conifer plantings. Commonly found associated with retired agricultural fields and Old Field Community where coarse perennial weeds have become established. In the Northern Highland, this species has responded favorably to intensive management for sharp-tailed grouse on sandy soils. Nests are usually found in association with sweet fern vegetation in areas of restored native prairie. Nesting clay-colored sparrows near the mouth of the Kinnickinic River in Pierce and Washington counties are associated with brushy open areas in Southern Deciduous Forest.

Field Sparrow (*Spizella pusilla*)

Status: Regular migrant and nesting species, casual early winter resident.

Migration: Fairly common to common migrant throughout the Valley. Locally distributed in heavily forested regions of the Northern Highland. Spring migrants arrive in the Western Upland about 10–20 April and the Northern Highland by 1 May. Peak spring migration through the Valley occurs late April to 15 May. Fall migration begins in the northern regions in late August and departure is by 15 September. Peak fall migration through the lower Valley occurs during 15–25 September and departure by 15 October.

Nesting Season Distribution: Fairly common and well-distributed nesting species in the Western Upland and Central Plain. Rare (locally common) nesting species in the Northern Highland. Bernard (1967) considered this sparrow a rare summer visitor and possible resident in Douglas County. Breeding Bird Survey data (Table 8) suggest that the field sparrow occurs fairly regularly during the nesting season in southern Douglas County. Roberts (1932) credited the removal of coniferous forest and replacement with a deciduous forest type with the expansion of this sparrow northward along the St. Croix River to southern Pine County.

Winter: Three winter records for St. Croix County from the Afton CBC, including single birds on 1 January 1971 and 1973, and three birds in one group on 1 January 1978. It is not known if any of these birds survived the winter. When the location of the 1978 birds was rechecked on 12 January 1978, the birds were not found.

Habitat: Characteristic nesting species of the Old Field Community where it is associated with early successional species including box elder, trembling aspen, staghorn sumac, and chokecherry. Use is also made of well-established growths of various coarse weeds in retired agricultural fields. During early stages of development, field sparrows are regularly encountered in

Pine Plantations. Deciduous Clear Cuts and brushy openings in Jack Pine Barrens are used in the Northern Highland.

Harris' Sparrow (*Zonotrichia querula*)

Status: Regular migrant, one winter record.

Migration: Rare spring and uncommon fall migrant in the Western Upland and Central Plain, casual in the Northern Highland. Spring migrants arrive in the Western Upland 1–5 May and are most frequently observed 10–20 May, departing by 25 May. Fall migrants arrive 20 September to 1 October. Peak fall migration occurs 10–20 October and departure by 30 October (latest—2 November 1968, St. Croix County).

Winter: One bird was recorded on the Afton CBC (Washington County) on 1 January 1974 (Eckert 1974). On 4, 8, and 11 April 1967 S. D. Robbins observed one at Roberts, St. Croix County, that he suspected of overwintering somewhere in the area.

Habitat: Primarily a species of brushy edges of fields and hedgerows. Observations of Harris' sparrows indicate that they migrate in close association with white-crowned sparrows.

White-crowned Sparrow (*Zonotrichia leucophrys*)

Status: Regular migrant, one winter record.

Migration: Uncommon migrant throughout the Valley. Spring migrants arrive in the Western Upland 25 April to 1 May (earliest—2 April 1961, St. Croix County), reaching the Northern Highland 1–5 May (earliest—20 April 1954, Burnett County). Peak spring migration occurs 10–25 May and departure by 30 May (latest—11 June 1953, Burnett County; Besadny 1953). Fall migrants arrive 5–10 September. Peak fall migration occurs 15–20 September and departure 25 September to 10 October.

Winter: One white-crowned sparrow was observed at a feeder in Luck, Polk County, on 23 December 1957 (Lound and Lound 1958*b*).

Habitat: Edges of deciduous woods that support a brushy understory, brushy edges of retired agricultural fields, hedgerows, and ornamental plantings in residential areas.

White-throated Sparrow (*Zonotrichia albicollis*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Abundant migrant throughout the Valley. The white-throated sparrow is second only to the song sparrow in abundance during migration. Spring migrants arrive in the Western Upland 1–10 April and the Northern Highland by 15 April. Peak spring migration occurs 20 April to 10 May and departure from nonbreeding areas occurs by 25 May. Fall migration begins in the Northern Highland in late August and the first birds reach the Western Upland 5–10 September (earliest—25 August 1977, Pierce County). Peak fall migration occurs 15 September to 10 October. Departure from the Northern Highland occurs 10–20 October and elsewhere by 15 November.

Nesting Season Distribution: Common nesting species in the Northern Highland (Table 8), uncommon and local in the Central Plain. Green and Janssen (1975) showed that the breeding range of this sparrow extended south to the Chisago–Washington County line. My most southerly nest record was obtained on 9 June 1975, near Luck, Polk County (Sec. 19, T. 36 N., R. 17 W.).

Winter: Rare and regular winter resident in the Western Upland. Usually encountered each year on either the Afton or Suburban St. Paul CBC. One remained at St. Croix Falls, Polk County, during the 1949–50 Winter.

Habitat: The white-throated sparrow occupies both deciduous and coniferous habitats during the nesting season. There is no single habitat that can be considered characteristic. Deciduous habitats that are most regularly used include stands of mature Northern Hardwood Forest with sugar maple, basswood, and silver maple the predominant vegetation. Nests in this habitat are usually associated with lush grasses and forbs in the ground layer. Deciduous Clear Cuts < 10 years old and predominantly trembling aspen with scattered patches of black raspberry are an important deciduous habitat. Coniferous habitats of major importance include Lowland Coniferous Forest dominated by yellow birch, white cedar, black spruce, and balsam fir. Extensive use is also made of Black Spruce–Tamarack Bogs. Use of Jack Pine Barrens is very low and irregular.

Fox Sparrow (*Passerella iliaca*)

Status: Regular migrant, casual early winter resident.

Migration: Fairly common migrant throughout the Valley. Spring migrants arrive in the Western Upland 15–25 March and the Northern Highland 1–5 April. Peak spring migration occurs 10–25 April and departure by 15 May (latest—28 May 1972, Washington County). Fall migrants arrive 10–15 September, peak fall migration occurs 1–20 October, and departure is by 15 November.

Winter: There are several early winter records from the Western Upland. These records include 13 December 1968, Chisago County, and 2 January 1960, 1 January 1970, 1974, and 1976 on the Afton CBC, Washington County.

Habitat: In the Western Upland, the fox sparrow is primarily a species of Southern Deciduous Forest characterized by white, Hill's, and bur oak. Extensive areas of brushy understory, primarily prickly ash, hazelnut, and beaked hazel are important components of that habitat. In the northern regions, fox sparrows use brushy edges and heavy undergrowth in Northern Hardwood Forest, primarily quaking aspen, sugar maple, basswood, white birch, and green ash.

Lincoln's Sparrow (*Melospiza lincolnii*)

Status: Regular migrant and possible summer resident.

Migration: Uncommon spring and fairly common fall migrant throughout the Valley, locally common in the Northern Highland. Spring migrants arrive in the Western Upland 1–5 May and the Northern Highland 5–10 May. Peak spring migration through the Valley occurs 10–20 May and departure 25 May to 1 June. Fall migration begins in the Northern Highland about 15 August with the first arrivals in the Western Upland 20–25 August. Peak fall migration occurs 15 September to 10 October and departure by 15–20 October (latest—28 October 1963, St. Croix County).

Nesting Season Distribution: S. D. Robbins (personal communication) recorded single Lincoln's sparrows along the route of the Minong BBS (Douglas County) on 16 June 1971 and 27 June 1975. On 26 June 1974 Robbins recorded one in an open bog about 6.4 km north of Moose Junction, Douglas County.

Habitat: Migrant Lincoln's sparrows are usually associated with brushy edge habitats. Old Field Community, retired agricultural fields, and ornamental shrubbery in residential areas are important among these. In the Northern Highland, this sparrow is regularly encountered in wet coniferous habitats, brushy borders of Northern Sedge Meadow, and in Alder Thickets.

Swamp Sparrow (*Melospiza georgiana*)

Status: Regular migrant and nesting species, one winter record.

Migration: Common migrant throughout the Valley. Spring migrants arrive in the Western Upland 25 March to 5 April and the Northern Highland 15–20 April. Peak spring migration through the Valley occurs 20 April to 5 May. Peak fall migration occurs 15 September to 10 October and departure by 20 October.

Nesting Season Distribution: Uncommon to fairly common nesting species in the Central Plain and Northern Highland, locally in the Western Upland. Jackson (1943) found the swamp sparrow "never particularly common" during the 1919 nesting season. He found nests with young at St. Croix Falls (Polk County) and Solon Springs (Douglas County). Breeding Bird Survey data (Table 8) suggest that the swamp sparrow is more abundant during the nesting season in the northern regions of the Central Plain and throughout the Northern Highland.

Winter: A single bird was observed in St. Croix County during the Afton CBC on 1 January 1970.

Habitat: Characteristic nesting species of Alder Thicket and Northern Sedge Meadow habitats in northern regions. Also fairly regular in Black Spruce–Tamarack Bogs and in open leatherleaf–Labrador tea bogs. In the Central Plain, this sparrow breeds regularly in Shrub Carr habitat which is dominated by heavy growths of gray dogwood and in cattail–bulrush vegetation associated with seasonally, semipermanently, and permanently flooded wetlands.

Song Sparrow (*Melospiza melodia*)

Status: Regular migrant, nesting species, and winter resident.

Migration: Abundant migrant throughout the Valley. Spring migrants arrive in the Western Upland 20 March to 1 April and the Northern Highland 1–10 April (earliest—13 March 1954, Burnett County). Peak spring migration occurs 15 April to 1 May. Peak fall migration is 1–10 September in the Northern Highland and 25 September to 10 October in the Western Upland. Departure from the Northern Highland occurs 15–25 October (latest—16 November 1975, Burnett County) and elsewhere by 5 November.

Nesting Season Distribution: Common nesting species throughout the Valley. Breeding Bird Survey data (Table 8) suggest that the song sparrow is the most abundant breeding sparrow in the Valley. Jackson (1943) reported that the song sparrow was a common nesting bird "at every locality visited" in northwestern Wisconsin in 1919. Goddard (1972) reported a breeding density of 40.3 pairs per 40 ha in the lower Kinnickinnic River Valley, Pierce County. Goddard also reported that the song sparrow was the second most abundant breeding bird among 82 species nesting in that valley.

Winter: Regularly occurring species during winter along the lower St. Croix River. Most birds are associated with feeding stations in residential areas.

Habitat: Nearly unrestricted in nesting habitat use. Important habitats are Shrub Carr, Alder Thicket, Prairie Wetlands, retired agricultural fields, Old Field Community, highway rights-of-way, and brushy openings in upland deciduous forest. Coniferous habitats are used to a lesser degree. Important among these are Black Spruce–Tamarack Bog and Lowland Coniferous Forest.

Lapland Longspur (*Calcarius lapponicus*)

Status: Regular migrant and winter resident.

Migration: Abundant migrant in the Western Upland, Central Plain, and unforested regions of the Northern Highland; rare in the heavily forested regions of the Northern Highland. Fall migrants arrive in the Northern Highland 15–20 September and the Western Upland 25 September to 1 October. Peak fall migration occurs 15 October to 15 November and most have departed by 1 December. Spring migrants arrive in the Western Upland 1–5 March and the Northern Highland about 15 March. Peak spring migration occurs 20 March to 10 April and departure by 10 May.

Habitat: An open country bird using primarily heavily grazed tame pasture, fall plowed agricultural fields, corn and oat stubble, and the exposed edges of Prairie Wetlands.

Winter: Uncommon winter resident of the Western Upland and Central

Plain, usually absent north of St. Croix Falls. Normal winter flock size is 10–30. The largest daily total on a CBC (Afton) is 174 on 1 January 1968.

Chestnut-collared Longspur (*Calcarius ornatus*)

Status: Accidental, one record.

Record: K. H. Dueholm observed three chestnut-collared longspurs in a flock of lapland longspurs on 20 March 1976, 4.8 km north of Star Prairie, Polk County.

Snow Bunting (*Plectrophenax nivalis*)

Status: Regular migrant and winter resident.

Migration: Common (locally abundant) migrant in the Western Upland, Central Plain, and unforested regions of the Northern Highland. Fall migrants arrive in the Northern Highland 10–20 October (earliest—5 October 1952, Burnett County) and the Western Upland 20–30 October. Peak fall migration occurs 10 November to 1 December. Peak spring migration occurs 1–15 March and departure by 15 April (latest—30 April 1971, Burnett County).

Winter: Fairly common (locally common) winter resident in the unforested areas of the Valley. Christmas Bird Count data suggest that largest numbers occur in the Central Plain and Northern Highland. The largest group on record (2,500) was recorded by N. R. Stone at Crex Meadows, Burnett County, on 21 December 1950.

Habitat: Primarily a species of open country using heavily grazed tame pasture, fall plowed agricultural fields, and corn or oat stubble. In the Northern Highland, occasional use is made of grassy railroad rights-of-way that traverse extensive hardwood forest stands.

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Appendix A

Common and Scientific Names of Plants Mentioned in Text

Species	Scientific name
Alfalfa	*Medicago sativa*
American elm	*Ulmus americana*
Arrowhead	*Sagittaria latifolia*
Awned sedge	*Carex atherodes*
Awnless bromegrass	*Bromus brizaeformis*
Balsam fir	*Abies balsamea*
Barley	*Hordeum vulgare*
Basswood	*Tilia americana*
Beaked hazel	*Corylus cornuta*
Bearberry	*Arctostaphylos uva-ursi*
Big bluestem	*Andropogon gerardi*
Big-leaf aster	*Aster macrophyllus*
Bindweed	*Convolvulus sepium*
Bishop's cap	*Mitella diphylla*
Black ash	*Fraxinus nigra*
Black cherry	*Prunus serotina*
Black raspberry	*Rubus occidentalis*
Black spruce	*Picea mariana*
Black willow	*Salix nigra*
Bladderwort	*Utricularia vulgaris*
Bloodroot	*Sanguinaria canadensis*
Blue bead lily	*Clintonia borealis*
Blue cohosh	*Caulophyllum thalictroides*
Blue vervain	*Verbena hasta*
Blueberry	*Vaccinium angustifolium*
Bluejoint grass	*Calamogrostis canadensis*
Bog birch	*Betula glandulosa*
Bog laurel	*Kalmia polifolia*
Bog rosemary	*Andromeda glaucophylla*
Bottle-brush grass	*Hystrix patula*
Box-elder	*Acer negundo*
Bracken fern	*Pteridium aquilinum*
Bristly sedge	*Carex comosa*
Brome grass	*Bromus* spp.
Brown sedge	*Carex buxbaumii*
Buckbean	*Menyanthes trifoliata*
Bunchberry	*Cornus canadensis*
Bur oak	*Quercus macrocarpa*
Burreed	*Sparganium eurycarpum*
Canada bluegrass	*Poa compressa*
Canada mayflower	*Maianthemum canadense*

Species	Scientific Name
Cane reed	*Phragmites communis*
Cattail	*Typha latifolia*
Choke cherry	*Prunus virginiana*
Common elder	*Sambucus canadensis*
Common milkweed	*Aesclepias syriaca*
Coontail	*Ceratophyllum demersum*
Corn	*Zea mays*
Cottongrass	*Eriophorum angustifolium*
Cottonwood	*Populus deltoides*
Creeping snowberry	*Gaultheria hispidula*
Crested sedge	*Carex cristatella*
Daisy fleabane	*Erigeron strigosus*
Dark-green bulrush	*Scirpus atrovirens*
Dogbane	*Apocynum androsaemifolium*
Downy yellow violet	*Viola pubescens*
Dwarf ginseng	*Panax trifolium*
Elodea	*Anacharis nuttallii*
Evening primrose	*Oenothera biennis*
False Solomon's seal	*Smilacina stellata*
Field mint	*Mentha arvensis*
Flowering crab apple	*Pyrus* spp.
Flowering spurge	*Euphorbia corollata*
Fox sedge	*Carex vulpinoidea*
Foxtail sedge	*Carex alopecoidea*
Germander	*Teucrium canadense*
Goat's beard	*Tragopogon pratensis*
Goosegrass	*Galium aparine*
Gray dogwood	*Cornus racemosa*
Great water dock	*Rumex altissimus*
Green ash	*Fraxinus pennsylvanica*
Ground pine	*Lycopodium clavatum*
Hardstem bulrush	*Scirpus acutus*
Hawthorn	*Crategus* spp.
Hazelnut	*Corylus americana*
Hedge nettle	*Stachys tenuifolia*
Hemlock	*Tsuga canadensis*
Hill's oak	*Quercus hillii*
Hoary alyssum	*Berteroa incana*
Indian pipe	*Monotropa uniflora*
Inland sedge	*Carex interior*
Intermediate wheatgrass	*Agropyron intermedium*
Iris	*Iris versicolor*
Ironwood	*Ostrya virginiana*
Jack-in-the-pulpit	*Arisaema atrorubens*
Jack pine	*Pinus banksiana*
Jacob's ladder	*Polemonium repens*
Jewelweed	*Impatiens biflora*

Species	Scientific name
Kentucky bluegrass	*Poa pratensis*
Labrador tea	*Ledum groenlandicum*
Large-flowered trillium	*Trillium grandiflorum*
Large-toothed aspen	*Populus grandidentata*
Leatherleaf	*Chamaedaphne calyculata*
Little bluestem	*Andropogon scoparius*
Manna grass	*Glyceria canadensis*
Marsh bellflower	*Campanula aparinoides*
Marsh cinquefoil	*Potentilla palustris*
Marsh milkweed	*Asclepias syriaca*
Marsh shield fern	*Dryopteris thelypteris*
Meadowsweet	*Spirea alba*
Moth mullein	*Verbascum blattaria*
Mountain ash	*Sorbus americana*
Mountain holly	*Nemopanthus mucronata*
New Jersey tea	*Ceanothus ovatus*
Noble goldenrod	*Salidago speciosa*
Northern bedstraw	*Galium boreale*
Oats	*Avena sativa*
Partridge berry	*Mitchella repens*
Pearly everlasting	*Anaphalis margaritacea*
Pennsylvania sedge	*Carex pennsylvanica*
Pickerelweed	*Pontederia cordata*
Pitcher plant	*Sarracenia purpurea*
Poison ivy	*Toxicodendron radicans*
Prickly ash	*Xanthoxylum americanum*
Purple-stem aster	*Aster puniceus*
Quack grass	*Agropyron repens*
Ragweed	*Ambrosia* spp.
Rattlesnake fern	*Botrychium virginianum*
Rattlesnake grass	*Glyceria canadensis*
Red clover	*Trifolium pratense*
Red maple	*Acer rubrum*
Red oak (Northern)	*Quercus borealis*
Red-osier dogwood	*Cornus stolonifera*
Red pine	*Pinus resinosa*
Reed canary grass	*Phalaris arundinacea*
Rice grass	*Oryzopsis asperifolia*
River bulrush	*Scirpus fluviatilis*
Round-leaf sundew	*Drosera rotundifolia*
Scotch pine	*Pinus banksiana*
Sharp-toothed goldenrod	*Solidago juncea*
Sheep sorrel	*Rumex acetosella*
Silver maple	*Acer saccharinum*
Silver willow	*Salix discolor*
Skunk cabbage	*Symplocarpus foetidus*
Slender sedge	*Carex lasiocarpa*

Species	Scientific Name
Small bedstraw	*Galium trifidum*
Softstem bulrush	*Scirpus validus*
Solomon's seal	*Polygonatum biflorum*
Soybean	*Glycine max*
Speckled alder	*Alnus rugosa*
Sphagnum moss	*Sphagnum* spp.
Spikerush	*Eleocharis* spp.
Spotted joe-pye weed	*Eupatorium maculatum*
Staghorn sumac	*Rhus typhina*
Starflower	*Trientalis borealis*
Sugar maple	*Acer saccharum*
Sweet cicely (Jarvil)	*Osmorhiza claytoni*
Sweet fern	*Comptonia peregrina*
Switchgrass	*Panicum virgatum*
Tall manna grass	*Glyceria grandis*
Tamarack	*Larix laricinia*
Tartarian honeysuckle	*Lonicera tartarica*
Tick trefoil	*Desmodium glutinosum*
Timothy	*Phleum pratensis*
Toothwort	*Dentaria laciniata*
Trembling aspen	*Populus tremuloides*
Turtlehead	*Chelone glabra*
Tussock sedge	*Carex stricta*
Twisted stalk (Rose mandarin)	*Streptopus roseus*
Virginia strawberry	*Fragaria virginiana*
Virginia waterleaf	*Hydrophyllum virginicum*
Water horehound	*Lycopus virginicus*
Water milfoil	*Myriophyllum* spp.
Water plaintain	*Alisma plantago-aquatica*
Water sedge	*Carex aquatilis*
Wheat	*Triticum aestivuum*
White ash	*Fraxinus americana*
White birch	*Betula papyrifera*
White cedar	*Chamaecyparis thyoides*
White oak	*Quercus alba*
White pine	*Pinus strobus*
White spruce	*Picea glauca*
White waterlily	*Nymphaea tuberosa*
Whorled loosestrife	*Lysimachia quadrifolia*
Wild cranberry	*Vaccinium macrocarpon*
Wild cranesbill	*Geranium maculatum*
Wild leek	*Allium tricoccum*
Wild lettuce	*Lactuca canadensis*
Wild rice	*Zizania aquatica*
Wild sarsaparilla	*Aralia nudicaulis*
Wintergreen	*Gaultheria procumbens*

Species	Scientific Name
Wood anemone	*Anemone quinquefolia*
Wood nettle	*Laportea canadensis*
Yarrow	*Achillea millefolium*
Yellow birch	*Betula alleghaniensis*
Yellow waterlily	*Nuphar variegatum*
Yellowish sedge	*Carex abacta*

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March 3, 1849

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